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Golder Associates

FINAL

BASELINE RISK ASSESSMENT
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Prepared by:

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July 1996

Project No.: 913-6773

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July 1, 1996

Project No.: 913-6773

USEPA Region III
841 Chestnut Building
Mailcode 3HW21
Philadelphia, PA 19107

Attn: Mr. Charles Root

RE: FINAL BASELINE RISK ASSESSMENT
BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA

Gentlemen:

On behalf of the Berks Landfill Respondents (Respondents), Golder Associates Inc. (Golder Associates) is pleased to submit to the US. Environmental Protection Agency (USEPA) three copies of the Final Baseline Risk Assessment (BRA) for the Berks Landfill Site located in Berks County, Pennsylvania. The Final Baseline Risk Assessment has been prepared in accordance with USEPA comments (dated January 23, 1995) on the Draft Baseline Risk Assessment submitted to USEPA on September 6, 1994. As indicated in USEPA's letter dated March 29, 1996, agreements to address the comments were made during a project meeting held between USEPA, Golder Associates, and representatives of the Respondents on March 9, 1995, and during follow-up discussions.

In addition to the USEPA comments, Golder Associates has made revisions to the Baseline Risk Assessment, as appropriate, to addresss the comments by Cabot Industries. As these comments were formally submitted to USEPA, USEPA has requested that the Respondents address them. A "red-lined" version of the Final Baseline Risk Assessment is also enclosed to assist USEPA in identifying the changes made to address all of the comments. A comment-by-comment response to both the USEPA comments and the Cabot Industries comments is presented below.

RESPONSE TO USEPA COMMENTS

I. Selection of Contaminants of Potential Concern (COPCS) in Environmental Media

Comment a: *Risk-based concentrations (RBCs) for cobalt and dibenzofurans are now available in the latest version of the Risk-based Concentration Table (attached).*

Response: Addition of the suggested RBC values for cobalt and dibenzofuran were completed in Tables 13, 14, 16, and 17 for cobalt and Table 14 for dibenzofuran. The text of sections 4.2.1 (paragraph 5 and 7), 4.2.2 (paragraph 2 and 3), and 4.2.4 (paragraph 1 and 2), for cobalt and 4.2.2 (paragraph 2) and 10.0 (paragraph 11) for dibenzofuran was also changed. However, none of the maximum detected values exceeded these levels, therefore, these changes did not affect selection of COPCs or any other part of the revised risk assessment.

Comment b: *Bis (2-ethylhexyl) phthalate detected in the Phase 1 sampling and analysis at levels above the RBC should be retained as a COPC. The assumption that the compound may not be present now because it was detected during the Phase 1 sampling and analysis only is not appropriate.*

Response: While bis(2-ethylhexyl)phthalate was not detected in any of the forty-four (44) Phase II groundwater samples, as directed by USEPA, potential risk estimates were evaluated separately for this compound. The potential risk associated with bis(2-ethylhexyl)phthalate as a carcinogen and a noncarcinogen was calculated for ingestion of on-site groundwater by adult and child receptors, and dermal contact with on-site groundwater while bathing. Tables 21, 22, and the risk tables for the receptors listed above were changed. The text of 4.2.1 (paragraph 8), was changed. However, the addition of bis(2-ethylhexyl)phthalate had no affect on Table 36 risk estimates or any aspect of the text related to risk characterization, and did not affect the revised risk assessment.

Comment c: *All of the monitoring wells should have been used to determine COPCs in ground water since all of the ground water is derived from the same aquifer. Accordingly, the risk assessment should have been based on contaminant levels in all of the wells.*

Response: After discussion with USEPA, it was agreed that the approach and wells used in the risk assessment are appropriate for this site and no additional wells would be used.

Comment d: *Shacklette soil background levels are no longer used to make a comparison with on-site levels. It is not clear why statistical analyses were not applied.*

Response: The mention of Shacklette in section 4.2.2 (paragraph 1) and its associated reference were deleted. It was agreed that no additional statistical analyses would be applied in the revised risk assessment.

Comment e: *The current draft soil lead guidance says that action may be taken at soil lead levels above 400 ppm for a residential site.*

Response: A value of 400 mg/L soil lead was used as an RBC rather than the 500-1000 reported previously in Tables 14 and 16. One sentence in section 4.2.2 (paragraph 2) was changed, however, this substitution had no effect on selection of COPCs for surface soil and sediment or any other aspect of the revised risk assessment.

Comment f: *The RBC for chromium VI should have been used for chromium. When it is used, chromium is a COPC.*

Response: Chromium (VI) was specifically analyzed for during the RI, but was not detected during Phase I sample analyses. Therefore, chromium (III) is the appropriate species to use in the risk assessment. The substitution of the current chromium (III) RBC value for all chromium in Tables 13, 14, and 17 had no effect on COPC selection.

II. Estimated RME Concentrations

Comment a: *The RME for off-site residents for a future scenario should not be assumed to be the same as that of the current off-site residents. Typically the future RME concentration is obtained from monitoring wells. The risk is assessed using the RME calculated from contaminant levels in monitoring wells, assuming there is an exposure point. There is an exposure point here. For example, ground water is assumed to flow off-site from the landfill.*

Response: After discussion with USEPA, it was agreed that based on the hydrogeologic setting, it is appropriate to use the current RME for off-site residents for a future scenario. Therefore, no changes were made in the Final Baseline Risk Assessment as a result of this comment.

Comment b: *The term "modeling exposures" should be changed to "estimating exposures."*

Response: All references to "modeling exposures" were changed to "estimating exposures" in sections 6.3.1 (paragraph 1), 6.3.2 (paragraph 1), 6.3.3 (paragraph 1), and 6.3.4 (paragraph 1).

Comment c: *Please provide sample calculations for the derivation of the RME and lognormality testing in the Appendix.*

Response: This risk assessment assumed a lognormal distribution. A sample RME calculation as described in detail in 6.0 of the risk assessment appears below.

Estimation of Exposure Concentrations

$$95\%\,UCL = e^{\left(\bar{y} + 0.5\,s^2 + \frac{sH_{1-\alpha}}{\sqrt{n-1}}\right)}$$

where:

UCL	=	upper confidence limit
e	=	the exponential function
$\bar{y}$	=	arithmetic mean of natural log-transformed data measurements
s^2	=	variance of natural log transformed data measurements
s	=	standard deviation of natural log transformed data measurements
$H_{1-\alpha}$	=	H-statistic value which depends on the degrees of freedom, n-1 and s (Gilbert, 1987)
n	=	the number of samples.

An example is demonstrated using arsenic in background groundwater.

Original Data[1]	Adjusted Data	ln of Adjusted Data
5.2 U	5	1.61
3.0 U	5	1.61
4.0 U	5	1.61
8.0 A	8	2.08
3.4 L	1.7	0.53
7.9 J	7.9	2.07
4.0 U	5	1.16
7.4 L	3.7	1.31
4.0 U	5	1.61
7.9 J	7.9	2.07

[1]Based on chemical concentrations in Monitoring Wells G-2, G-3, G-7, G-8, and G-10; Residential Wells CASS, REIFSNYDER, and HEINZ.

For U values, half the laboratory detection limit was used. For J values, the laboratory reported value was used. For K and L values, half of the value reported by the laboratory was used. Mean of ln of adjusted data(y) = 1.61, variance of ln transformed adjusted data (s^2) = 0.211, standard deviation of ln transformed adjusted data (s) = 0.46, n = 10, and H-statistic = 2.22 (Gilbert, 1987) for n=10, s = 0.5.

$$95\%UCL = e^{(1.61+0.5*0.211+\frac{0.46*2.22}{\sqrt{10-1}})}$$

= 7.82 µg/L or 0.008 mg/L

III. Toxicity Assessment

Comment a: ***The oral RfD for chloroethane is 4E-01 mg/kg/day, not 2.0E-02 mg/kg/day.***

Response: The oral RfD for chloroethane was changed in Table 19 and used to calculate the RBC value in Table 17 as suggested, however, these changes had no affect on the revised risk assessment.

Comment b: ***The inhalation RfD for toluene is 1.14E-01 mg/kg/day, not 1.0E-01 mg/kg/day.***

Response: The inhalation RfD for toluene was changed in Table 19 and Appendix E risk calculations for inhalation of on-site air by a child trespasser and adult worker as suggested. However, these changes had no affect on the risk to any receptor or the revised risk assessment in general.

Comment c: ***The inhalation RfD for arsenic is 1.51E+01, not 5.0E+01.***

Response: The inhalation slope factor (CSF) for arsenic was changed in Table 20 as suggested, however, this change had no affect on the revised risk assessment.

IV. Exposure Assessment

Comment a: ***"Future exposures to maintenance workers at the Site are expected to occur 24 days per year." Please provide the data in the Appendix as previously suggested.***

Response: Typically, operation and maintenance activities at closed municipal solid waste landfills are varied and include routine cover/surface water management system inspection and maintenance, leachate and/or groundwater system routine monitoring, operation and maintenance, and specialized activities such as cover and pump repairs, etc. These activities are typically performed throughout the year by several different people with specific skills and experience for a particular task. One person does not typically perform all of the operation and maintenance activities required at a closed landfill (e.g., landfill cap inspections are not typically done by the same person who extracts and rebuilds a pump).

Golder Associates has prepared a number of municipal solid waste landfill post-closure operation and maintenance plans which have been approved by regulatory agencies, such as:

- Coakley Landfill, New Hampshire
- Shelton Landfill, Connecticut
- Chesterfield County Landfill, Virginia
- G.R.O.W.S. Landfill, Pennsylvania
- Monroe Township Landfill, New Jersey
- Blydenburgh Road Landfill, New York
- Warren County District Landfill, New Jersey

In general, landfill inspections and routine maintenance are performed quarterly to annually. Some inspections may be required more frequently but at a shorter duration. Therefore, based on our experience, twenty-four 8-hour days is a reasonable exposure duration for a single maintenance worker to perform routine inspection and maintenance activities as well as to perform non-routine tasks as they arise at a landfill.

Comment b: ***In addition to future on-site residents, ground water use should be assumed for future off-site residents.***

Response: Risk associated with groundwater use by off-site residents was calculated and included in the risk assessment. Specifically, risks associated with dermal contact by a child, ingestion of groundwater by a child and adult, and inhalation of volatile organics from showering by an adult were evaluated (Appendix E). These exposure routes are shown in Table 26 of the risk assessment document.

Comment c: *The air emissions model ("Box Model") used to estimate exposure concentrations from the contaminants emitted from the landfill vents inappropriately assumed a mixing height of 700 meters. The mixing height should have been no greater than 2 meters. Class D stability should have been assumed, not Class C stability, since it is more conservative.*

Response: As agreed during discussions, air emissions modeling using the box model was conducted using a mixing height of 300 meters and Class D stability. Text in section 8.4 (paragraph 1) and Appendix D was modified to reflect this change.

Comment d: *Experimentally measured permeability coefficient values for benzene, cadmium and nickel should have been used, not the predicted values.*

Response: Experimentally measured permeability coefficient values for benzene, cadmium, and nickel were substituted in calculations presented in Tables 17, 32, and 36 as suggested. These values were also used in calculations in risk tables for dermal contact in Appendix E. These changes had no effect on the revised risk assessment.

V. Risk Characterization

Comment a: *The newest version of the Uptake/Biokinetic Lead Model is Version.99. Please make a note of this change.*

Response: The text in section 9.4 (paragraph 1 and 2) was changed to reflect that Version .99 was used in the evaluation.

Comment b: *The RME concentration for lead of 56 µg/L exceeds the action level for lead of 15 µg/L. Approximately 22% of the population may have lead levels above 10 µg/dL if they ingest drinking water with lead levels at the levels reported. This is despite the geometric mean being below 10 µg/dL. Please include a probability distribution graph in the Appendix to show this increase in blood lead level in the general population and recharacterize the risk.*

Also, it is not clear whether the lead levels reported are for filtered or unfiltered samples. Filtered samples are usually used in risk assessment.

Response: The IEUBK model was used to evaluate potential effects of exposure to lead in on-site groundwater and lead in a future residential exposure scenario. Average lead concentrations in soil and groundwater were used as site-specific model inputs. The use of average concentrations is in accordance with guidance for the IEUBK model.

VI. Uncertainty Analysis

Comment a: *The statements regarding potential risk posed by arsenic in ground water are too strong. Arsenic at the levels reported in ground water may pose a significant risk whether or not they occur in background ground water at the same levels.*

Response: The text was changed to reflect the reviewers concern for the wording used to discuss the background risk posed by arsenic in groundwater in section 10.0 (paragraph 7 and 8).

Comment b: *Note that vinyl chloride toxicity in young children (e.g., infants) may be twice that for adults. The Report says that the "vinyl chloride toxicity factor for incidence of carcinogenicity is overly conservative." This statement is not consistent with what is known about vinyl chloride toxicity today.*

Response: The text of section 10.0 (paragraph 9) was changed to read, "The above study, thus, suggests that the use of the vinyl chloride toxicity factor for incidence of carcinogenicity may overestimate risk."

VII. Discussion

Comment: *The excess cancer risk and HI estimates for potential background (upgradient), and on-site (downgradient) ground water exposures are mainly attributable to the presence of arsenic and manganese in these areas. Please add manganese to this statement.*

Response: The word manganese was added to this sentence in section 11.0 (paragraph 5).

RESPONSE TO CABOT INDUSTRIES COMMENTS

Response to Comment I:

It is acknowledged that there is uncertainty with regard to the oral carcinogenicity of beryllium via ingestion. However, beryllium still is considered a class B2 carcinogen according to the USEPA Integrated Risk Information System (IRIS), and was evaluated as such in the risk assessment. Until USEPA alters its view of beryllium, the Berks Landfill Respondents have continued to use IRIS. Therefore, no changes with regard to beryllium as an oral carcinogen via ingestion were made in the revised risk assessment.

Response to Comment II:

The use of RBC values is the recommended approach according to USEPA Region III and guidelines, therefore, no changes were made regarding beryllium as a COPC.

Response to Comment III:

The guidance cited in the comment clarifies the evaluation of the baseline risk assessment results and is not used in the screening of contaminants for inclusion in the risk assessment. Specifically, the guidance discusses the role of the baseline risk assessment in developing remedial action alternatives and supporting risk management decisions (USEPA, 1991c). The baseline risk assessment for Berks Landfill appropriately presents both background and site related calculated risks. The decision to eliminate constituents and, thus, their risks because they are below the MCL, or ARARs, is left for consideration by risk managers, as suggested by USEPA.

Response to Comment IV:

The text of sections 9.3.1 (paragraph 1), 10.0 (paragraph 10), and 11.0 (paragraph 4) were changed to reflect that uncertainty is associated with estimated hazard indices because manganese is considered an essential nutrient.

Response to Comment Va:

The use of RBC values is an acceptable approach according to USEPA guidelines, therefore, comparison to MCL or MCLG values was not conducted.

Response to Comment Vb:

The text of section 11.0 (paragraph 3 and 5) was changed to reflect more strongly that on-site concentrations of aluminum, arsenic, beryllium, and lead are attributable to background and are not site-related.

Response to Comment Vc.1:

A paragraph was added in section 3.0 (paragraph 4) discussing these uncertainties.

Response to Comment Vc.2:

As stated in the correspondence in Appendix A and section 3.0 of the risk assessment, the use of half the laboratory reported value for K and L qualified data was part of the approach agreed upon with the USEPA before the risk assessment was conducted. No changes were made in the revised risk assessment.

Response to Comment Vd.1:

The correct gas velocity of 1.63×10^{-5} m/sec was used in the original assessment but Appendix D incorrectly listed the gas velocity as 1.63×10^{-6} m/sec. Appendix D was modified accordingly. Therefore, there was no effect on modeled exposure concentrations.

Response to Comment Vd.2:

The C_i term in equation (1) of Appendix D is not a soil gas concentration, it is an estimate of volatilization and is represented by the RME gas concentration emitted from the passive landfill vents. Appendix D was clarified by changing the C_i term to "calculated RME concentrations from passive landfill vent gasses".

Response to Comment Vd.3:

A mixing height of 300 meters and Class D stability was used in the revised risk assessment as agreed upon with the USEPA. The resultant changes were incorporated in Table D-1 and risk calculations for inhalation of air by an adult off-site receptor, inhalation of air by an on-site adult resident, child trespasser, and adult worker. The resultant changes in calculated risk were also incorporated into Table 33, 34, 35, and 36 and the text of sections 8.4 (paragraph 1), 9.3.2 (paragraph 3), 9.3.3 (paragraph 3), 9.3.4 (paragraph 3), 9.3.5 (paragraph 2 and 3), and 11.0 (paragraph 3) was modified to account for these changes. However, these changes had a negligible effect on the overall risks at the site.

Response to Comment Vd.4:

Appendix D listed the landfill area of 2.67 x 10^6 m^2 but the correct landfill area of 2.67 x 10^5 m^2 was actually used in the model, therefore, Appendix D was modified to clarify this issue. A length of 617 m rather than 434 m (reflecting the downwind length of both landfills combined) was used in the revised risk assessment. Appendix D was also revised to reflect this change and the modified air concentrations were incorporated in Table D-1 and the risk calculations for inhalation of air by an adult off-site receptor, and inhalation of on-site air by a child trespasser, adult worker, and adult resident. The text of sections 8.4 (paragraph 1),), 9.3.2 (paragraph 3), 9.3.3 (paragraph 3), 9.3.4 (paragraph 3), 9.3.5 (paragraph 2 and 3), and 11.0 (paragraph 3) was revised to account for these changes. However, these changes had a negligible effect on the overall risks at the site.

Response to Comment Vd.5:

Conservative assumptions have been used and it is intended as a screening tool to estimate maximum potential exposures to off-site receptors. Potential exposures are likely less than those estimated by this model.

Response to Comment Vd.6:

The calculations in equation (3) are conservative due to assumptions used in modeling exposures. For the on-site receptors, a simple box model is used to estimate exposure point concentrations above which potential exposures are unlikely to occur. The model is intended as a conservative screening tool and likely overestimates any potential exposures. Similarly, the Gaussian dispersion plume model is used to estimate off-site exposures. Conservative exposure assumptions have been used in this model including Class D atmospheric conditions, an emission rate based on maximum concentrations detected in landfill vents, and a wind direction which is constantly toward the receptor. The conservatism of both these models is supported by the fact that no detectable concentrations of any of the COPCs were identified in ambient air sampling. If risks and hazard quotients estimated by these conservative models are within established criteria, then no additional modeling is required.

Response to Comment Ve:

These exposure parameters were agreed to with the USEPA and the risk assessment was not modified.

Response to Comment Vf:

Time weighted averages were calculated and Tables 32, 33, and 36 and the text of sections 9.3.1 (paragraph 1 and 4), 9.3.2 (paragraph 2, 4, and 6), 9.3.5 (paragraph 3), and 11.0 (paragraph 2, 3, and 4) were revised to reflect these changes.

Response to Comment Vg:

The text of the uncertainty section 10.0 (paragraph 9) discussing vinyl chloride carcinogenicity was changed to reflect this fact.

Response to Comment VIa:

The risk assessment uses USEPA risk-based screening concentrations from "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening" (USEPA, 1994a) as noted in the footnotes of Tables 13, 14, 16, and 18. RBC values in Tables 13, 14, 16, and 18 were based on a conservative HQ of 0.1 used Region III Risk-Based Concentration Tables rather than 1. The footnote in each of these revised tables stated that the RBC values came from "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening "and based on a conservative HQ of 0.1. These changes had no effect on the selection of COPCs or the revised risk assessment.

Response to Comment VIb - bullets a-g:

The ranges presented in Tables 1 through 12 reflect the minimum and maximum concentrations reported by the laboratory. Due to the application of USEPA directives in calculating the mean, and the fact that only certain monitoring wells were used for groundwater assessment, the mean and maximum values used later in the assessment may not match or fall within the range reported in Tables 1 through 12. Footnotes in Table 13, as well as sections 4.0 (paragraph 2) and 4.2.1 (paragraph 2 and 9) of the text have been changed to further clarify this fact.

h The title of Table 25 was revised to address the comment.

i In Table 30, the soil ingestion rate units were changed to mg/day.

j The source of the CA term in Table 31 was revised to reflect that values came from Table D-1 and Appendix D.

k Risk estimates were checked for accuracy in rounding and all appropriate changes were made to Tables 32 through 36.

l The modeled concentrations for hydrogen sulfide were recalculated, as well as the associated risk calculations in Appendix E. Table D-1 and the risk tables in Appendix E were revised. The text in sections 8.4 (paragraph 1), 9.3.2 (paragraph 3 and 4), and 11.0 (paragraph 3) were also revised to clarify the confusion noted in comments h, j, l, and m.

m Appendix D, Table D-1, all the modeled VOC concentrations, and associated risks in Appendix E were revised to reflect these changes. Specifically, risk tables in Appendix E for inhalation of air by an off-site adult receptor, and inhalation of air by an on-site child trespasser, adult worker, and adult resident were revised.

Please do not hesitate to call should you have questions regarding the Final Baseline Risk Assessment.

Very truly yours,

GOLDER ASSOCIATES INC.

Randolph S. White

Randolph S. White, P.E.
Project Director and Associate

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cc: R. Klinikowski, PADER
R. Bishop, PADER
K. Chung, American Geotech
Berks Landfill Respondents

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EXECUTIVE SUMMARY

Golder Associates Inc. (Golder Associates) has prepared this Baseline Risk Assessment (BRA) on behalf of the Berks Landfill Respondents as part of the Remedial Investigation (RI) for the Berks Landfill Site (Site) located in Spring Township, Berks County, Pennsylvania. Portions of the Site were historically used for municipal waste landfilling operations from the 1950's through 1986 under varying ownerships. Landfilling ceased in 1986 and the landfill was closed in accordance with a Consent Order issued by PADER. During and after the operation of the landfill, numerous environmental investigations were conducted. The United States Environmental Protection Agency (USEPA) proposed the Site for inclusion on the Comprehensive Environmental Response, Cleanup and Liability Act (CERCLA) National Priorities List (NPL) on June 24, 1988, and it was formally included on the NPL on October 2, 1989.

On July 5, 1991, the USEPA and the Berks Landfill Respondents entered into an Administrative Order on Consent (Consent Order) to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the Site. During the course of the RI, USEPA agreed that the Berks Landfill Respondents could perform the BRA at the Site and Golder Associates prepared a Work Plan, which was approved by USEPA on January 6, 1994. The Consent Order was modified to include a Baseline Risk Assessment.

A Draft BRA was submitted to USEPA on September 6, 1994 and USEPA comments on the Draft BRA were provided to the Berks Landfill Respondents on January 23, 1995. Subsequently, USEPA approved the Remedial Investigation Report and approach to address the USEPA comments on the Draft BRA in a letter dated March 29, 1996.

The major objective of the BRA is to characterize the potential risks to human health and the environment associated with exposure to constituents identified at the Site in the absence of any further remediation or institutional controls (i.e., under an assumption of no further action). The BRA was conducted in accordance with an approved USEPA Work Plan, USEPA approved procedures and applicable USEPA national and Region III guidance documents.

The chemicals of potential concern (COPCs) in environmental media at the Site (groundwater, surface soil, surface water, sediment, leachate lagoon water, leachate seep water, and ambient air) were selected primarily in accordance with the USEPA (1994a) Region III Technical Guidance Manual. Specifically, the rationale for selecting COPCs in environmental media was based on (1) risk-based concentrations screening; and (2) the evaluation of essential human nutrients. USEPA screening concentrations for soil were used for the evaluation of sediment COPCs. In the case of surface water, leachate lagoon water, and leachate seep water, for which screening concentrations have not been developed by USEPA, risk-based concentrations were calculated in the BRA and used for selecting COPCs in these media.

For purposes of this BRA, the reasonable maximum exposure (RME) concentrations were used as exposure point concentrations for the Site in accordance with USEPA guidelines. The RME is defined as either the maximum detected concentration or the 95% upper confidence limit (95% UCL) on the arithmetic mean, whichever is lower.

The identification of potential exposure pathways and exposed populations in the BRA was based mainly on the RI report (Golder Associates, 1995), Site-specific conditions, local land use patterns and ecology, and the activities of nearby residents. Potential exposures, under both current and hypothetical future land use of the study area, were also postulated. The potential exposure pathways to human receptors were identified in the BRA as: ingestion, dermal contact, and inhalation of volatiles in groundwater; incidental ingestion and dermal contact with surface soil; dermal contact with surface water, sediment, leachate lagoon water, and leachate seep water; and inhalation of volatiles from passive landfill gas vents.

The results of the Risk Assessment are summarized below. Given the comparison of background with off-site and on-site risks, it appears that much of the calculated risks from exposure to inorganic constituents (i.e., metals) are being driven by non Site-related sources, particularly naturally occurring metals in bedrock and soil.

The estimated potential total cancer risk for a hypothetical residential receptor to background groundwater (as determined from upgradient monitoring wells) and background surface soil chemical concentrations, under current and future exposure scenarios, is 3×10^{-4}. The total hazard index (HI) estimate for potential exposure to these background media concentrations is 14. These risk estimates are primarily attributable to detected concentrations of arsenic and/or beryllium in background groundwater and soil. The total cancer risk estimate (3×10^{-4}) from potential background exposure exceeds USEPA's acceptable excess cancer risk range of 10^{-4} to 10^{-6}, while the HI value also exceeds the recommended Agency criterion of 1 by several fold (i.e., fourteen times).

The data show that risks attributable to exposure to background constituent concentrations exceed the risk estimates for the off-site resident. The estimated potential total cancer risk for an off-site resident theoretically exposed to both background and Site-related constituents, as detected in off-site downgradient residential wells, is 2×10^{-4}. This estimate only slightly exceeds the USEPA acceptable range of 10^{-4} to 10^{-6}. The estimated HI for an off-site resident does not exceed the recommended criterion of 1 when additivity of different toxic endpoints is evaluated as recommended by USEPA (1989a). However, the risk estimates for potential exposure to background media concentrations (as noted above) are greater than the estimates for total off-site residential exposures. That is, 3×10^{-4} as compared with 2×10^{-4} for cancer risks associated with background and off-site residential exposure, and 14 as compared with 1 for noncancer risks. The cancer risk estimate is primarily attributable to arsenic concentrations.

The results of this BRA demonstrate that the background risks are higher than potential off-site residential risks. In addition, the infrequent and detected low concentrations of organic chemical constituents in residential well water resulted in an estimated potential excess cancer risk of 2×10^{-6}, which is well within USEPA's acceptable risk range.

The only potential risk exceeding USEPA's target risk range is the estimated potential total cancer risk of 1×10^{-3} for a hypothetical on-site resident under a future use scenario. Also, the total HI of 50 for potential future on-site residents is in exceedance of the recommended criterion of 1. These risk estimates are attributable to the presence of vinyl chloride, arsenic, and manganese concentrations in groundwater. It is important to bear in mind that future on-site residential use is remote. In addition, given the conservative nature of the risk assessment process, it is likely that the risk estimates in this BRA will actually exaggerate potential health risks.

In the case of potential exposure by off-site residents to modeled volatile compounds in air, under current and future use scenarios, the potential excess cancer risk of 2×10^{-5} is within the range of 10^{-4} to 10^{-6} cancer risk levels deemed acceptable by USEPA. It should be pointed out that the air transport models used in the BRA are based on very conservative exposure parameters that tend to overestimate chemical concentrations at the point of exposure. In addition, none of the detected chemicals in actual ambient air monitoring samples from leachate lagoons, leachate seep water, or at the Site perimeter exceed USEPA Region III risk-based screening concentrations.

The assessment of both cancer and noncancer risks for potential on-site trespasser exposure to both air and surface soil constituents, under both current and future scenarios, indicate that the estimated risk values are below USEPA acceptable risk range of 10^{-4} to 10^{-6} for carcinogens and a HI of 1 for noncarcinogens. Similarly, the estimated cancer risk and HI for potential future on-site worker exposure to both air and surface soil constituents are also below the USEPA acceptable risk range.

The potential health risk estimates derived in this BRA are likely overestimated, with each conservative assumption building on the previous one. This approach is designed to compensate for inherent uncertainties in the use of risk assessment results for making risk management decisions. The contribution of cancer and noncancer risks due to "background" sources is an area of uncertainty associated with the COPCs at Berks Landfill. As noted above, arsenic, beryllium, and manganese are detected at similar concentrations in background (upgradient) locations, off-site residential wells, and on-site (downgradient) monitoring wells. The potential lifetime excess cancer risk estimates associated with exposure to these metals in background samples exceeds the estimated risks for off-site residential groundwater. Consequently, potential risk from the ingestion of these constituents may be attributed to groundwater conditions which exist upgradient of the Site, or are unrelated to the Site (e.g., naturally occurring rock).

There are no available toxicity factors with which to evaluate potential exposure to lead concentrations in groundwater. However, the USEPA has developed a biokinetic/uptake model (Version 0.99) for lead with which to assess potential exposures to children. This model was used in the BRA to evaluate potential exposures of child residents in the future to lead in on-site groundwater. Based on this model, blood levels for children are projected at the Berks Landfill Site to be below USEPA's benchmark of 10 ug/dL for all age groups.

The Ecological Risk Assessment at Berks Landfill focused on a representative species (i.e., meadow vole) for the characterization of the potential risks to primary receptors exposed to chemical constituents in soil within the terrestrial habitat. The results of this assessment suggest that on-site soils are not expected to pose potential adverse effects to the meadow vole.

A comparison of constituents detected in sediments and surface water to applicable federal water quality criteria and Pennsylvania State water quality standards relative to the protection of aquatic life indicate no exceedances, thereby, suggesting that the Site is not expected to pose potential adverse effects to aquatic receptors in surface water and sediment. This conclusion is supported by the aquatic habitat assessment conducted during the remedial investigation which did not indicate any potential Site-related impact on surface water/sediment receptors or their community structure.

In summary, the results of this BRA indicate that no current or future potential populations are at risk of developing unacceptable potential health risks because of hypothetical exposures to chemicals of potential concern in sediment, surface water, surface soil, or air at the Site. For potential exposure to groundwater, because detected metals are present at higher concentrations in background (upgradient) wells as compared to off-site downgradient residential wells, potential risks should be attributed to naturally occurring groundwater conditions. The BRA and remedial investigation have concluded that potential risk to off-site residential receptors attributable to the Site is negligible and does not transgress acceptable limits.

The only estimated potential health risk which exceeded the USEPA acceptable range is the case of an on-site resident and the likelihood of this future use is extremely remote. Indeed, given the conservative nature of the risk assessment process, it is likely that the noncarcinogenic and carcinogenic risk estimates calculated in this BRA actually exaggerate the potential risks associated with the chemicals of concern at the Berks Landfill.

Finally, the chemicals detected in leachate exceed criteria levels; however, leachate seeps and ponds are not considered to be a wildlife habitat, and support only limited aquatic life at the landfill. Therefore, the results of the ecological assessment demonstrate that the chemicals of interest in environmental media at the Site do not pose potential adverse effects to primary ecological receptors.

1.0 INTRODUCTION

Golder Associates Inc. (Golder Associates) has prepared this Baseline Risk Assessment (BRA) on behalf of the Berks Landfill Respondents as part of the Remedial Investigation (RI) for the Berks Landfill Site (Site) located in Spring Township, Berks County, Pennsylvania. The major objective of the BRA is to characterize the potential risks to human health and the environment associated with exposure to constituents identified at the Site in the absence of any further remediation or institutional controls (i.e., under an assumption of no further action). A brief description of the Site, history of related activities, and a summary of the RI results are presented in this section based on information provided in the RI report (Golder Associates, 1995). The reader is referred to the RI report for a more complete description of the Site and the RI procedures and results.

1.1 Background

Portions of the Site were historically used for municipal waste landfilling operations from the 1950's through 1986 under varying ownerships. From 1975 through 1986, landfilling at the Site was conducted under a "Permit for Solid Waste Disposal and/or Processing Facility" issued by the Pennsylvania Department of Environmental Resources (PADER). Landfilling ceased in 1986 and the landfill was closed in accordance with a Consent Order issued by PADER. During and after the operation of the landfill, numerous environmental investigations were conducted. The United States Environmental Protection Agency (USEPA) proposed the Site for inclusion on the Comprehensive Environmental Response, Cleanup and Liability Act (CERCLA) National Priorities List (NPL) on June 24, 1988, and it was formally included on the NPL on October 2, 1989.

On July 5, 1991, the USEPA and the Berks Landfill Respondents (Sonoco Fibre Drum, Inc., Carpenter Technology Corporation, and The Glidden Company), entered into an Administrative Order on Consent (Consent Order), Docket No.: III-90-32-DC, to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the Site. Under the Consent Order, the Berks Landfill Respondents were required to complete the RI/FS and USEPA was to conduct the BRA. The Remedial Investigation was conducted by Golder Associates in accordance with the Consent Order and a RI/FS Work Plan approved by USEPA on June 8, 1992. During the course of the RI, USEPA requested that the Berks Landfill Respondents prepare a Work Plan for conducting the BRA at the Site. USEPA approved the BRA Work Plan and Golder Associates as the contractor for the BRA on January 6, 1994. The Consent Order was then modified to include the BRA.

The USEPA approved BRA Work Plan, including the submittal of two interim deliverables which presented the selection of chemicals of potential concern (Interim Deliverable No. 1) and identified exposure pathways and factors (Interim Deliverable No. 2) which were used in the BRA. These interim reports were submitted to USEPA on March 3, 1994. USEPA provided written review comments to Golder Associates on April 11, 1994. Based on these review comments and subsequent telephone conversations with USEPA, Golder Associates submitted a response to comment letter to USEPA specifying the final approach agreed to with the Agency for conducting the BRA. These documents provide the framework of the BRA and are presented in Appendix A for reference.

A Draft BRA was submitted to USEPA on September 6, 1994 and USEPA comments on the Draft BRA were provided to the Berks Landfill Respondents on January 23, 1995. Subsequently, USEPA approved the Remedial Investigation Report and approach to address the USEPA comments on the Draft BRA in a letter dated March 29, 1996.

1.2 Site Description and Setting

The Site, as defined in the Consent Order, consists of two closed municipal refuse landfills and associated features located south of Wheatfield Road, two residences along Wheatfield Road (one of which is upgradient of the landfills and the other of which was destroyed by fire), and predominantly undeveloped forested property north of Wheatfield Road as shown on Figure 1. The two closed landfills are referred to as the eastern landfill, which covers an area of approximately 47 acres, and the western landfill, which covers an area of approximately 19 acres. Figure 1 presents a topographic base map of the Site and shows the main Site features.

1.2.1 Eastern Landfill

The eastern landfill includes access roads, security fencing, former landfill operations buildings, and four lined leachate collection lagoons. The access roads both on and off of the landfill are gravel. An 8-foot high chain link security fence with locking gates also surrounds the eastern landfill, including the lagoons. Landfilling of predominantly municipal refuse and demolition debris reportedly began in the 1950's and continued through 1986. Some industrial wastes were also reportedly disposed of at the landfill. A portion of the eastern landfill is reportedly underlain by a compacted low permeability soil liner. A leachate collection system was installed and is currently operating for the lined portion of the landfill. Leachate is conveyed to the leachate collection lagoons which incorporate an automated pumping system to the publicly owned treatment works. In addition, several passive gas vents have been installed on the landfill. The eastern landfill was closed in 1986, and covered with a vegetated soil cap. The soil cap consists of a graded and compacted low permeability soil cover with erosion control side slope benches and rip-rap lined channels to convey surface water off of the landfill.

1.2.2 Western Landfill

The western landfill reportedly received predominantly municipal refuse and some industrial waste and alkali sludges. Landfilling activities occurred from the 1960's until the mid-1970's. Following closure during the 1970's, the western landfill was covered with a graded, low permeability soil cap. The side slopes of the landfill, which were closed in the early to mid 1970's, are currently covered by deciduous woodlands with trees estimated to be up to 20 years in age. The crown of the landfill, which was capped around 1980, is currently covered with grasses and shrub/brush vegetation. Leachate collection drains are believed to have been installed along the northeast portion of the landfill and connected to the leachate collection lagoon associated with the eastern landfill. Two passive landfill gas vents were installed in the western landfill. Access roads surround the landfill.

1.2.3 Other Major Site Features

An unnamed tributary to Cacoosing Creek, and its associated wetlands and riparian zone, lies approximately parallel to Wheatfield Road and flows in an east-to-west direction through the Site. The Cacoosing Creek tributary is a perennial stream which originates east of the Site. A Spring Township sewer main is aligned adjacent to the Cacoosing Creek tributary channel. In at least two locations, the sewer line is exposed within the channel. Two small surface water drainageways (the central and western drainageways) originate south of the Site and flow across the Site to their confluence with the Cacoosing Creek tributary.

Two private residences are located along Wheatfield Road within the Site. The Cass residence is located north of Wheatfield Road at the eastern portion of the Site and is upgradient of the landfills. The Nein residence, which burned down in November 1993 and remains unoccupied, is located south of Wheatfield Road approximately mid-way between the east and west Site boundaries. Except for the Cass residence, the property north of Wheatfield Road is undeveloped and wooded along a fairly steep southern facing slope on an east-west trending ridge. Former mine workings are located just north of

Wheatfield Road within this wooded area. One business (Zerbe's Auction House) is located at the Site south of Wheatfield Road.

Land use in the vicinity of the Site is zoned industrial/commercial and residential. The 1988 Existing Land Use Map developed for the Berks County Comprehensive Plan (Berks County Planning Commission, December 1991) designates the majority of the Site for industrial use because the land was previously devoted to landfilling activities. The Site is surrounded by woodlands, agricultural fields and sparsely populated residential areas. Undeveloped deciduous woodlands are located east, west, and north of the Site. Agricultural fields are located to the south. Residential homes are located along Wheatfield Road both east and west of the Site, along Chapel Hill Road located west of the Site, and along Gelsinger Road located north of the Site. In general, the residences along Chapel Hill Road and Gelsinger Road are separated from the Site by topographic ridges. The residences along Wheatfield Road are located within the valley containing Wheatfield Road and the Cacoosing Creek tributary.

1.3 Summary of the Remedial Investigation

The RI was performed in three phases of field investigation, Phase 1A, 1B, and 1C, and involved extensive programs of subsurface exploration, field testing, sampling, chemical analyses, geotechnical analyses, and data evaluation. The investigation defined the geology, hydrogeology, construction of the existing landfill caps, and other features of the Site; assessed wetlands, and aquatic and terrestrial habitats; determined the nature and extent of constituents detected at the Site; and, determined potential fate mechanisms and transport pathways available to these constituents.

Landfill Cap Investigation

The landfill cap investigation determined that the existing cap on the eastern landfill was constructed with a relatively good degree of quality control regarding thickness, compaction, and grading. The eastern landfill side slopes are well vegetated and surface water control benches direct runoff from the steeper areas of the landfill to rip-rap lined channels. In general, the existing conditions on the eastern landfill are consistent with the Nassau-Hemsley engineers closure plan diagrams, approved by PADER, which show a 2-foot thick soil cap layer with graded and benched side slopes. The existing cap on the western landfill, while exhibiting lower cap thicknesses and field densities than the eastern landfill, also appears to have been compacted and graded during closure and has heavily vegetated side slopes.

The materials used to construct the caps are generally well suited as landfill cap materials based on the measured large proportion of fines, low permeability, and low susceptibility for volume change. Overall, the existing cap materials are generally of the quality and character appropriate for landfill caps and are performing many of the functions for which they were designed.

Geologic Investigation

The results of the geologic investigation determined that the intrusive diabase mass is the most important geologic feature at the Site with respect to groundwater flow. The diabase mass is present beneath and generally encircles the Site in a saucer-like configuration, providing a physical and hydraulic barrier. The diabase and its orientation have been identified through regional geologic mapping performed by the U.S. Geological Survey, Golder Associates' surface geology mapping at and in the vicinity of the Site, and subsurface exploration borings performed by Peffer Geotechnical Corporation and Golder Associates. The lithologies overlying the diabase at the Site have been identified, however, they do not influence groundwater flow as significantly as the diabase which hydraulically controls groundwater flow due to its orientation and low permeability.

Hydrogeologic Investigation

The results of the hydrogeologic investigation conducted at the Site indicate the presence of two flow systems: a shallow water table aquifer, and a deeper semi-confined flow system. Groundwater flow within the water table aquifer is topographically controlled with flow toward and discharging to the Cacoosing Creek tributary system. Flow within the deeper system is controlled by the diabase, which exhibits high hydraulic heads and low permeability, as seen in packer testing conducted at the Site. These characteristics result in lateral flow to the north and then upward flow in a westerly direction along the Cacoosing Creek tributary system. Within the Creek system, the two groundwater flow systems tend to merge and flow toward the west with an overall upward trend eventually discharging to the Cacoosing Creek tributary as surface water or as subsurface base flow. The diabase acts as both a physical and hydraulic barrier which prevents downward flow in the deeper flow system at the Site.

Ecological Assessment

The ecological assessments conducted during the RI included wetlands, terrestrial habitats, and aquatic habitats at the Site. Approximately 16 acres of stream corridor wetlands along the surface water drainageways and the Cacoosing Creek tributary were identified at the Site. In addition, seepage wetlands, which did not exist prior to landfill construction are present on the landfill surface. Seven major terrestrial habitat types were identified at the Site. Plant and wildlife species lists were developed based on observations made at the Site and the Pennsylvania Fish and Wildlife species database. Numerous off-site and ecologically similar terrestrial habitats were determined as having no significant differences from the on-site terrestrial habitats. The results of the benthic macroinvertebrate survey showed that aquatic habitats upstream of the Site were found to be ecologically similar to the aquatic habitats downstream of the Site. This similarity between background and the Site shows that the Site aquatic habitats support normal abundant benthic communities rich in taxa diversity. No Site-related impacts to these aquatic habitats or their community structure were observed.

Sampling and Analyses

Environmental sampling and analyses were conducted in three phases (Phase 1A, 1B, and 1C). Phase 1A samples were selected at "worst case" locations or locations suspected of having the highest potential for the presence of Site-related constituents in order to establish chemicals of potential concern (COPC) in groundwater, soil, leachate, surface water, sediment, and air. Each Phase 1A sample was analyzed for the complete Contract Laboratory Protocol target compound list and target analyte list of constituents. Following the completion of the Phase 1A sampling and analyses, USEPA selected the COPC for further evaluation during Phase 1B and 1C which focused on assessing the extent of the COPC in the various environmental media.

Forty-two groundwater well samples (including one mine drainage sample), fifty-one residential and business well samples, eleven surface water samples, fourteen sediment samples, twenty-two soil samples, and eight leachate samples were collected and analyzed during Phase 1A, 1B, and 1C. For the air media, a comprehensive field screening program was conducted during Phase 1A and seventeen air samples were collected for laboratory analysis during Phase 1B.

Fate and Transport Characteristics

Several factors were identified as affecting the fate and transport of constituents detected in the various environmental media at the Site. Generally, metals are expected to be persistent in environmental media while VOCs and SVOCs will be less persistent primarily due to biodegradation and volatilization. Constituents detected in leachate seeps and soil may be transported to surface water and sediments via erosion and precipitation runoff and, to a lesser extent, to groundwater via infiltration. However, the RI data shows that the VOCs and SVOCs detected in soil are not impacting surface water and the VOCs likewise are not impacting sediments. A comparison of background (upstream) data indicates that the constituents detected in surface water and sediments can generally be attributed to non Site-related sources.

The primary transport mechanism for VOCs at the Site is groundwater flow with eventual discharge to surface water. The RI demonstrated that this pathway is well defined with regard to the direction of flow and definition of the discharge location. Groundwater flow at the Site follows topography northward to the Creek system where the water is channeled westward through the water table aquifer in a relatively narrow cross-sectional area at the west end of the Site. Deep flow components are controlled both physically and hydraulically by the presence of a low permeability high head diabase unit which underlies the Site. Thus, the eventual discharge of groundwater flow from the Site (both shallow and deep flow) is to the Creek system which consists of the Cacoosing Creek tributary surface water and subsurface base flow. Although constituents from the landfill have been detected in groundwater at the Site, they have not been detected in surface waters. This may be attributed to the natural processes of dilution, biodegradation, adsorption, and/or volatilization within the Cacoosing Creek tributary system.

Based on the RI results, constituents detected in soil, leachate, surface water and sediment are generally present in background and/or upstream samples and/or are present at concentrations generally less than regulatory criteria. In addition, VOCs are present in on-site groundwater which has been shown to discharge to the surface water drainageways and the Cacoosing Creek tributary system. However, as noted above, these constituents have not been detected in surface water, probably because of the fate and transport processes listed above.

2.0 SITE RISK ASSESSMENT METHODOLOGY

The methodology followed in the BRA for assessing potential risks at Berks Landfill is based on the BRA Work Plan interim deliverable report Nos. 1 and 2 and subsequent Agency directives (see Appendix A). In addition, pertinent Agency risk assessment guidelines are used, including procedures described in the Risk Assessment Guidance for Superfund (RAGS) Volumes I and II (USEPA 1989a, 1989b), Exposure Factors Handbook (USEPA, 1989c), Supplemental Guidelines for Exposure Assessment (1991a), and USEPA Region III Technical Guidance Manuals for Risk Assessment (USEPA, 1991b; 1994a).

Risk assessment is a four-step process developed by the National Academy of Sciences (NAS, 1983) and is used by a number of groups and regulatory agencies, such as the USEPA. The process includes the following:

- Hazard Identification - the evaluation of potential adverse health effects (toxicity) of chemicals to which individuals may be potentially exposed;
- Dose-Response Assessment - the analysis of how adverse health effects change in frequency of occurrence, intensity, duration, and magnitude of exposure;
- Exposure Assessment - the estimation of the frequency, duration, and magnitude of human exposure to chemicals; and,
- Risk Characterization - the determination of the probability of the occurrence of health effects in potentially exposed individuals.

This BRA report is structured in accordance with the suggested format in RAGS, Part A (1989a). The sections included in the BRA report are as follows:

Section 3.0: Data Evaluation and Summary Statistics
The validated analytical data from the environmental media at the Site are evaluated for useability in the BRA and for summary statistics.

Section 4.0: Chemicals of Potential Concern
Chemicals of potential concern (COPCs) that are associated with the Site are identified in various environmental media.

Section 5.0: Toxicity Assessment
The health hazards associated with COPCs are identified, and the relationship between dose and response is evaluated to derive toxicity values for use in estimating the incidence of adverse effects at different exposure levels.

Section 6.0: Estimation of Exposure Concentrations
Exposure concentrations are estimated for each COPC in various environmental media for identified exposure pathways.

Section 7.0: Exposure Assessment
A Site characterization in the context of potential exposure is provided, including receptor population analysis. The exposure pathways are defined and identified in terms of COPC source and receiving media, fate and transport in the release media, exposure points, and exposure routes under both current and reasonable future Site conditions.

Section 8.0: Estimation of Human Intakes
Measured or predicted exposure point concentrations are combined with exposure parameters to derive estimates of human intake or dose.

Section 9.0: Risk Characterization
Toxicity criteria are combined with estimates of human intake to quantify potential health hazards or risks associated with COPCs.

Section 10.0: Uncertainty Analysis
The uncertainties related to components of the BRA, including estimates of potential risk, are evaluated qualitatively.

Section 11.0: Discussion and Conclusions
A discussion of the potential risk estimates from exposure to COPCs is presented. Also presented are conclusions that are based on results of the risk assessment.

Section 12.0: Ecological Risk Assessment
Ecological receptors in the Site vicinity are identified, and the potential risks to these receptors are assessed, using available qualitative and quantitative toxicity information.

The environmental media analytical data used in the BRA are based on the groundwater, surface soil, sediment, surface water, leachate lagoon water, leachate seep water, and air sampling activities (Phase 1A, 1B, and 1C) presented in the RI report (Golder Associates, 1995). The exposure pathways and receptors evaluated in the BRA are based on the conceptual Site model discussed in Section 1.0 and further characterized in the RI report (Golder Associates, 1995).

3.0 DATA EVALUATION AND SUMMARY STATISTICS

The Phase 1A, 1B, and 1C RI data have been validated using the USEPA National and Region III data validation guidelines. USEPA Region III data qualifiers were also used. The analytical data packages and validated data summary tables have been previously submitted to USEPA (Golder Associates, 1994). The following USEPA Region III directives to Golder Associates, in the application of analytical data, are used for performing the BRA:

- Data qualified B, K, or L (as defined by USEPA Region III guidance for data validation) are not included in the selection of COPCs. Only the maximum detected values of A (acceptable) and J (estimated) qualified data are used in selecting COPCs for the Site. While the use of "A" for data qualification does not strictly follow USEPA Region III guidance, it has been used during the Berks Landfill RI for clarity to identify unqualified or acceptable data.

- Data qualified B are not used in the remainder of the BRA.

- The laboratory reported value is used as the detected result for data qualified with either an A or J.

- For those constituents, where a non-detect value (i.e., U, UL, and UJ qualifiers) was reported for a given sample, the value used in the calculation of summary statistics is one-half of the sample quantitation limit (SQL), or contract required detection limit (CRDL), for organic and inorganic constituents, respectively.

- In the case of the data qualified as K or L, one-half of the reported value is used for the summary statistics calculation.

- For a given sample, constituents that were detected in blank samples are not considered to be Site-related or detected unless the sample concentration exceed the level in the blank(s) by five times or more. The sample concentration of common laboratory contaminants (*viz.*, acetone, 2-butanone, phthalate esters, methylene chloride, and toluene) would have to exceed the concentration in the blank(s) by ten times or more to be considered Site-related.

- N or R qualified data are excluded from both the determination of the frequency of detection of a chemical and in the calculation of the mean concentration.

- For re-analyzed samples, the higher of the two reported concentrations is used for the purpose of estimating mean concentrations and frequency of detection. In the case of duplicated samples, reported concentrations are averaged for calculating overall mean concentrations.

Chemical constituents were detected in environmental media during the Phase 1A, 1B, and 1C RI activities at the Site. Summary statistics of validated analytical data, including the frequency of detection, concentration range, and arithmetic mean of detected constituents in groundwater, surface soil, surface water, sediment, leachate lagoon water, leachate lagoon seep water, and air are presented in Tables 1 through 12. The ranges presented in the tables represent the minimum and maximum concentrations reported by the laboratory. Due to the application of USEPA directives in calculating the mean of the data, the mean value presented may not fall within the range reported in Tables 1 through 12. Media are divided into subgroups to provide summary statistics of the chemical constituent data defining background conditions and potential on-site and off-site exposure levels. The following is a list of environmental media subgroups and the respective summary statistics table numbers:

- Upgradient (Background) Groundwater (Table 1);
- Downgradient (On-Site) Groundwater (Table 2);
- Off-Site Residential Well Groundwater (Table 3);
- Off-Site (Background) Surface Soil (Table 4);
- On-Site Surface Soil (Table 5);
- Up-Stream (Background) Surface Water (Table 6);
- On-Site Surface Water (Table 7);
- Up-Stream (Background) Sediment (Table 8);
- On-Site Sediment (Table 9);
- Leachate Lagoon Water (Table 10);
- Leachate Seep Water (Table 11); and,
- Ambient Air (Table 12).

It should be noted that the procedures used to calculate chemical constituent summary statistics for the BRA differ slightly from that used in the RI. For example, summary statistics calculated during the RI did not include sample data where the SQL or CRDL exceeded twice the maximum detected concentration in that media (as per guidance on data useability in risk assessment, USEPA, 1990). However, in accordance with recent USEPA directives, these data were included in the BRA summary statistics. Therefore, the summary statistics presented in the RI may not precisely match the summary statistics presented in this report, in all cases.

In addition, there is uncertainty in the precision of concentration measurements near the instrument detection limit. The measured concentrations of arsenic and beryllium are within two times the instrument detection limits commonly reported by analytical laboratories for these metals. Therefore, depending on the analytical instrumentation and methodology used, the reported arithmetic means may be less than the method detection limit. As a result, uncertainty is associated with measured levels of arsenic and beryllium. For manganese, factors such as turbidity and iron content of the sample may interfere with quantitation. Therefore, uncertainty may also be associated with measured manganese concentrations.

4.0 CHEMICALS OF POTENTIAL CONCERN

The COPCs at the Site are primarily selected in accordance with the USEPA (1994a) Region III Technical Guidance Manual. As stated in this document, the selection process is designed to identify chemical constituents that are most representative of potential human health risks from exposure routes at a site. In particular, the rationale for selecting COPCs at the Site is based on the following:

- Risk-based concentrations screening; and,
- Evaluation of essential human nutrients.

As recommended in USEPA (1994a) guidelines, maximum detected concentrations of chemical constituents in environmental media at the Site are compared with risk-based screening concentrations developed by the Agency for groundwater, soils, and air (Tables 13, 14, and 18, respectively). The maximum concentrations presented in Tables 13, 14, and 18 are screened according to USEPA directives and may not reflect the maximum concentrations presented in Tables 1 through 12. Because the majority of the Site, including the landfill areas, is currently zoned for industrial use (Berks County Planning Commission, December, 1991), and because all on-site soil samples are from the landfilled areas, the *commercial/industrial screening risk-based concentrations* are used for selecting COPCs in soils. In addition, the screening concentrations for soils are also used for sediments in this BRA (Table 16) because of the nonavailability of media-specific risk-based concentrations for the latter. These Site-specific approaches have been previously approved by USEPA Region III for use in this BRA (see Appendix A).

In the case of surface water, leachate lagoon water, and leachate seep water, for which screening concentrations have not been developed by USEPA Region III, risk-based concentrations were calculated in the BRA, and used for selecting COPCs in these media at the Site. The approach used, as agreed to with USEPA (see Appendix A), is based on potential exposure to surface water and leachate via dermal contact during wading and/or trespassing activities at the Site. The equations and exposure parameters provided in Appendix I of the USEPA Region III Technical Guidance Manual (USEPA, 1994a) and Section 6.6 of the RAGS Manual (USEPA, 1989a), are used in the calculation of risk-based screening concentrations for surface water and leachate media. The methodology and exposure parameters used in these calculations are presented in Appendix B of this BRA report. The calculated risk-based screening concentrations for surface water and leachate media are presented in Tables 15 and 17, respectively.

The measured maximum constituent concentrations in environmental media are compared with risk-based screening concentrations. As indicated in Tables 13 through 18, constituents which have maximum observed concentrations in exceedance of USEPA (1994a) Region III (or calculated) risk-based screening concentrations and/or action levels are shaded.

4.1 Evaluation of Essential Nutrients

The RAGS (1989a) manual recommends that chemicals that are: (1) essential human nutrients; (2) present at low concentrations (i.e., only slightly elevated above naturally occurring levels or background); and (3) are toxic only at very high doses (i.e., much higher than those which could be associated with contact at the Site) should be eliminated from consideration, in order to focus potential risk on the "most significant" chemicals.

Thus, inorganic chemicals that are classified as essential nutrients and which have relatively low toxicity at low concentrations (*viz.*, calcium, iron, magnesium, potassium, and sodium) are eliminated as COPCs in environmental media at the Site.

4.2 Selection of COPCs in Environmental Media

4.2.1 Groundwater

Several metals were detected in groundwater samples at similar concentrations in both background and downgradient monitoring wells at the Site. Two statistical methods were used to compare hydraulically upgradient (background) metal concentrations with concentrations from hydraulically downgradient wells, as presented in the RI report (Golder Associates, 1995). The two methods (discussed in detail in the RI report) are (1) the Tolerance Interval approach as described in the USEPA (1989d) guidance document, and (2) the Wilcoxon Two-Sample Test as discussed in Sokol and Rohlf (1969).

The Tolerance Interval approach calculates the UTL, or, the upper 95% confidence limit of the concentration of a metal in background groundwater, followed by a comparison to downgradient data. Downgradient metal concentrations that were less than the UTL were, thus, considered to be attributable to background conditions. The Wilcoxon Two-Sample Test compares two data sets (background and on-site monitoring wells) and was used in the RI report to, respectively, test the following null and alternative hypotheses:

H_O: The populations from which the two data sets have been drawn have the same mean (i.e., the test does not show a significant difference between the two sample sets); and,

H_A: The populations have different means (i.e., the test shows a significant difference between the two sample sets).

The results of the statistical analysis of the upgradient groundwater metals data (total and dissolved) in comparison with the downgradient data indicate that, in general, on-site detected concentrations of aluminum, arsenic, beryllium, lead, and manganese are less than calculated UTLs for background groundwater. It is noteworthy that, with the exception of manganese, the Wilcoxon Two-Sample Test also did not show a statistically significant difference between the upgradient groundwater data and the on-site data sets for these chemicals.

It should also be pointed out that the presence of metals detected at the Site is not unexpected because of the existence of the municipal solid waste, background conditions, and the nature of the geologic materials. In particular, the geologic studies conducted at the Site revealed the presence of pyroxenes, feldspars, limestones, magnetite, carbonates, iron, and various sulfide minerals. In fact, the Site contains mine working from contact metamorphic scarn ore deposits, which often contain various trace metals containing mineral assemblages which can dissolve into groundwater. Therefore, it is possible that most of the metals detected in groundwater may be associated with the rock beneath the Site.

As indicated in Table 13, the maximum concentrations of several inorganic constituents detected in both background (upgradient) and on-site (downgradient) groundwater exceed the USEPA (1994a) Region III risk-based screening concentrations. Consequently, selected inorganic COPCs for both background and on-site groundwater will be separately evaluated in the BRA.

The BRA is considering only inorganic constituents in background groundwater. The rare detection of organic constituents (bromomethane, chloromethane, and 1,2-dichloroethane) in background groundwater is not included in the assessment of potential background risks because these compounds are not considered to be naturally occurring. Rather, these organic constituents may be a result of localized impact from a residence or from other unknown sources. As discussed in the RI, organic constituents were generally not detected in background groundwater.

Based on the above rationale, the following chemical constituents, as indicated in Table 13, are selected as COPCs for the groundwater medium:

Background Groundwater	On-Site Groundwater	
Aluminum	Aluminum	Benzene
Arsenic	Arsenic	Carbon Disulfide
Beryllium	Barium	Chlorobenzene
Cadmium	Beryllium	Chloromethane
Copper	Cadmium	1,4-Dichlorobenzene
Lead	Copper	1,1-Dichloroethane
Manganese	Lead	1,2-Dichloroethane
Nickel	Manganese	1,1-Dichloroethene
Vanadium	Vanadium	Total-1,2-Dichloroethene
		Hexachloroethane
		Trichloroethene
		Vinyl Chloride

Off-Site Residential Groundwater	
Arsenic	Chloroform
	1,2-Dichloroethane
	1,1,2-Trichloroethane

Bis(2-ethylhexyl)phthalate, which is a common laboratory contaminant, was detected at low levels in 10 on-site groundwater samples during the Phase 1A sampling event. However, this semivolatile compound was not detected in any of the 44 groundwater samples that were collected and analyzed as part of the Phase 1B investigation at the Site. Thus, this compound may no longer be present at detectable levels at the Site. Furthermore, while the Phase 1A data validation did not qualify the constituent as blank-related, the detection of this constituent may have been attributed to sampling or laboratory contamination during the Phase 1A investigation. However, as directed by USEPA, bis(2-ethylhexyl)phthalate was evaluated separately for potential risk.

It should be noted that, following USEPA (1991b) Region III guidance, the selection of COPCs in on-site groundwater is based on the data from a subset of monitoring wells believed to be representative of the reasonable maximum exposures for the hypothetical future residential use scenario (i.e., monitoring wells C-5, G-1, G-4, G-5, G-6, G-12, G-13, MP-14S, and MP-14D). Consequently, the maximum concentrations presented in Table 13 may not reflect maximum values reported in Table 2. These wells are located in the portion of the Site where future residential exposures are possible (albeit unlikely) and include the highest concentrations detected in that area. The rationale for the selection of the monitoring wells is fully described in Section 6.1 of this BRA report.

4.2.2 Surface Soil

As indicated in Table 14, maximum detected concentrations of beryllium in on-site surface soil (2.0 mg/kg) exceed the USEPA (1994a) risk-based screening concentration of 0.67 mg/kg. However, the detected maximum concentration in background soils (1.5 mg/kg) also exceeds the Agency-recommended screening value. Therefore, beryllium is believed to be related to background conditions and will be separately evaluated in the BRA for both background and on-site exposure scenarios as directed by USEPA (see Appendix A).

There is no available USEPA risk-based screening concentration or toxicity factor available for the assessment of lead. The USEPA (1994e) has indicated that 400 mg/kg of lead in soil is considered to be protective of sensitive subpopulations (such as children) for potential residential exposure. It is, however, noteworthy that Site-related samples are well below these levels (Table 14).

Based on the above rationale, the following compounds, as indicated in Table 14, are selected as COPCs for the surface soil medium:

<u>Background Soil</u>	<u>On-Site Soil</u>
Beryllium	Arsenic Beryllium Manganese Benzo(a)pyrene

4.2.3 Surface Water

Table 15 indicates that none of the detected chemical constituents in surface water exceed the calculated risk-based screening concentrations. Therefore, COPCs are not selected for the surface water medium at the Site because the detected chemicals in surface water do not pose potential health risks greater than recommended USEPA regulatory levels.

4.2.4 Sediment

As indicated in Table 16, the maximum detected concentrations of three inorganic chemicals (arsenic, beryllium, and manganese) exceed USEPA (1994a) risk-based screening concentrations in both background and on-site sediments. Hence, these chemicals are believed to be related to background conditions, or, are naturally occurring at the Site. Therefore, they will be separately evaluated in the BRA for both background and on-site exposure scenarios.

Based on the above rationale, the following chemicals, as indicated in Table 16, are selected as COPCs for the sediment medium:

Background Sediment	On-Site Sediment
Arsenic	Arsenic
Beryllium	Beryllium
Manganese	Manganese

4.2.5 Leachate

As indicated in Table 17, none of the detected chemicals in leachate lagoon water or leachate seep water at the Site exceed calculated risk-based screening concentrations. It should be noted that there are no available toxicity factors with which to calculate risk-based concentrations for lead and 4-chloro-3-methylphenol. In general, heavy metals (such as lead) are, however, not dermally absorbed in their pure unbound state. In addition, 4-chloro-3-methylphenol at a detected concentration of 2.0 µg/L in leachate seep water is not expected to pose unacceptable health risk at the Site due to the low level of detection which is, comparatively, below the risk-based screening concentrations for some of the more toxic compounds detected in these media.

Based on the above rationale, no COPCs are selected for the leachate lagoon water or leachate seep water at the Site because the detected chemicals in these media do not pose potential health risks greater than recommended USEPA regulatory levels.

4.2.6 Air

As presented in Table 18, none of the ambient air samples from lagoon, leachate seep, Nein residence, and perimeter locations exceeded Agency-derived screening concentrations. The maximum concentrations of some chemical compounds detected in air monitoring samples from passive vents at the Site did exceed USEPA (1994a) risk-based screening concentrations. There are no available risk-based screening concentrations for 1,2-dichloro-1,1,2,2-tetrafluoroethane and 4-ethyl toluene. However, these compounds, at their detected low concentrations in air, are not expected to pose any potential health risks that will be greater than recommended USEPA regulatory levels.

Based on the above rationale, the following constituents detected in passive gas vents (Table 18) are selected as COPCs for the air medium:

<u>Air</u>

Benzene	Trichloroethene
Chlorobenzene	Vinyl Chloride
Chloroethane	Total Xylenes
Ethylbenzene	Dichlorodifluoromethane
Hydrogen Sulfide	1,2,4-Trimethylbenzene
Toluene	1,3,5-Trimethylbenzene

These COPCs are selected for ambient air in order to perform a very conservative assessment of potential risks from exposure to airborne chemicals both on-site and downwind of the Berks Landfill. It should also be emphasized that none of the chemicals detected in ambient air, either on-site or at the property boundary, exceed Agency screening levels. Potential receptors are also not expected to inhale pure landfill gas at the Site.

5.0 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to identify the potential adverse health effects associated with exposure to Site-related substances and to evaluate, using numerical toxicity values, the likelihood that these adverse effects may occur. The toxicity assessment for this risk assessment is conducted in accordance with RAGS (USEPA, 1989a).

In general, toxicity assessment is conducted in two stages: hazard identification and dose-response evaluation. Hazard identification is the determination of whether the exposure to an agent will result in an increase in the incidence of adverse health effects, while dose-response evaluation is the process of quantitatively characterizing the relationship between the dose of a chemical and the corresponding incidence of deleterious effects in an exposed population (USEPA, 1989a). Toxicity information on chemicals is available in the Agency for Toxic Substances Disease Registry (ATSDR) Toxicological Profiles, the scientific literature, Health Effects Assessment Summary Tables (HEAST) (USEPA, 1993a), and some on-line databases such as the Integrated Risk Information System (IRIS) (USEPA 1994b).

5.1 Toxicity Information for Noncarcinogenic Effects

Systemic toxic effects other than cancer can be associated with exposures to chemicals. The reference dose (RfD) is the toxicity value which is used to evaluate the noncarcinogenic effects resulting from exposure to a chemical. The RfD has been developed on the premise that protective mechanisms exist that must be overcome before an appreciable risk of adverse health effects is manifested during a defined exposure period. That is, there is a threshold dose which must be exceeded before adverse effects are likely to occur. The RfD is developed to reflect the duration of exposure (e.g., subchronic and chronic exposures), and the route of exposure (i.e., inhalation and oral).

Chronic exposure is defined in RAGS (USEPA, 1989a) as a repeated or prolonged exposure (i.e., from seven years to a lifetime). The chronic RfD is a daily exposure level that will likely not result in an appreciable risk of deleterious effects from lifetime exposure to the general population, including sensitive subpopulations. For purposes of this BRA, the chronic RfD is utilized to evaluate noncarcinogenic effects which may be associated with potential exposure to the COPCs at the Site.

Carcinogens may also have systemic effects other than cancer. Carcinogens are thus evaluated for potential noncarcinogenic toxic effects and are included in the determination of chronic toxicity hazard indices which characterize noncancer hazards. Carcinogenic effects, however, are usually manifested at levels that are significantly lower than those associated with systemic toxic effects; thus, cancer is usually the predominant adverse effect for chemicals that elicit carcinogenic as well as noncarcinogenic responses.

Two chronic toxicity parameters that are used in establishing RfDs are the lowest-observed-adverse-effect levels (LOAELS) and the no-observed-adverse-effect levels (NOAELS). The LOAEL may be defined as the lowest exposure level at which there is a demonstrated statistically and/or biologically significant increase in adverse effects between the exposed animal population and the control group in a toxicological study. The NOAEL is the exposure level at which there are no demonstrated adverse effects in a dose-response toxicity study. Uncertainty factors may be further applied to the reported NOAELs or LOAELs in order to adjust for data limitations, and for differences between experimental animal exposure conditions and human exposures (NAS, 1977). These factors also account for inherent variability in human responses to chemical agents, and for general imprecision in extrapolating from laboratory animals to humans. The noncarcinogenic toxicity values (i.e., RfDs) developed by the USEPA and the corresponding critical effects for the COPCs at the Site are summarized in Table 19.

5.2 Toxicity Information for Carcinogenic Effects

Potential human carcinogenic effects are evaluated based on the chemical-specific slope factors and the weight-of-evidence classifications of the USEPA. The weight-of-evidence classification is applied to the determination of the probability of cancer occurrence in humans, based on the strength of human epidemiological and/or animal study data. This system, originally developed by the International Agency for Research on Cancer (IARC), has been slightly modified by the USEPA (1986a). Carcinogens are classified by the USEPA according to the following weight-of-evidence categories:

- Group A - Human Carcinogen

  There is sufficient evidence from epidemiological studies that substantiates a causal association between exposure and carcinogenicity in humans.

- Group B1 - Probable Human Carcinogen

  There is a limited evidence of carcinogenicity in humans from available epidemiological data.

- Group B2 - Probable Human Carcinogen

  There is sufficient evidence of carcinogenicity in animals, but inadequate or no evidence in humans.

- Group C - Possible Human Carcinogen

  There is a limited evidence of carcinogenicity in animals.

- Group D - Not Classifiable

  The evidence for carcinogenicity in animals is inadequate to support classification.

- Group E - Human Noncarcinogen

  There is no evidence of carcinogenicity for humans based on adequate studies.

The cancer slope factor (SF) is the toxicity value that quantitatively defines the dose-response relationship of a known or suspected carcinogen. The SF is an estimate of an upperbound lifetime probability of an individual developing cancer following a chronic lifetime exposure to a potential cancer-causing agent. Slope factors for chemicals are expressed as the 95% upper confidence limit of the slope of the dose-response curve. The SF is derived by assuming a low-dose linearity and applying a computer model to extrapolate from the relatively high doses administered to animals (or the exposures observed in epidemiological studies) to the lower environmental exposure levels that generally occur in humans. The Carcinogen Assessment Group (CAG) of the USEPA has developed upperbound SFs for carcinogens, based on the premise that there is no threshold or level of exposure below which carcinogenic effects will not be elicited.

Because the SF is the 95% upper confidence limit of the probability of a response per unit intake of a chemical over a lifetime exposure, there is only a 5% chance that the response will be greater than the estimated value. The use of SFs, thus, results in a conservative (i.e., upperbound) estimate of potential cancer risk. That is, the true risk to humans is not likely to exceed the upperbound estimate, but may in fact be lower. Further, because the dose-response curve is assumed to be linear in the low-dose region, the accuracy of the SF may be limited if this region should, in reality, exhibit nonlinearity. The carcinogenic toxicity values (i.e., slope factors), the corresponding weight-of-evidence classifications, and the types of cancer for the COPCs at the Site are summarized in Table 20.

5.2.1 Adjustment of Toxicity Factors

As stated in RAGS (USEPA 1989a), for purposes of conducting risk assessment for potential dermal exposure to chemicals at hazardous waste sites, it is necessary to adjust an oral toxicity factor (i.e., RfD or SF) from an administered to an absorbed dose. Because most of the oral toxicity values for the COPCs at this Site are expressed as administered doses (i.e., intake-based), it is necessary to adjust both the RfDs and SFs for these compounds in estimating potential dermal exposure to affected media. Thus, the estimated dermally absorbed doses may be appropriately compared with toxicity factors that are expressed as absorbed doses.

Toxicokinetic information from the available literature is generally used to determine the extent of dermal absorption for COPCs. An appropriate oral absorption efficiency (expressed as percent absorbed) is identified, and the factor is applied to the RfD and/or SF to determine the corresponding dermally adjusted toxicity index. RfD values are adjusted by multiplying by the oral absorption efficiency, while SF values are adjusted by dividing by the oral absorption efficiency (USEPA, 1989a).

The available information in the literature suggests that oral absorption efficiencies for inorganic chemicals are typically in the range of 5 to 10%, as gastrointestinal (G.I.) absorption is likely to be affected by several factors. Such factors include chemical form (e.g., organic or inorganic), and diet. The scientific literature indicates that most organic compounds are readily, and almost completely absorbed in the G.I. tract. Therefore, no adjustments are made for those chemicals with absorption efficiencies approaching 100% because of the magnitude of the uncertainties inherent in the development of toxicity factors. Available G.I. absorption factors in the literature and adjusted RfDs and SFs are presented in Table 21. In the absence of chemical-specific absorption data, estimates are utilized in the BRA based on data for chemically related substances.

5.2.2 Uncertainties Associated with Toxicity Assessment

An overview of the uncertainties associated with the toxicity information utilized in the BRA is presented in this section. This overview includes a discussion of the possibility of overestimating or underestimating health risks or hazards; the bioavailability and the absorption efficiencies of COPCs; and the limitations of the dose-response extrapolation model utilized by the USEPA for assessing carcinogenic risks.

5.2.2.1 Chemical-Specific Toxicity Factors for Chemicals

Because the toxicities of inorganics are compound-specific, the chemical species used in a toxicological study may not be indicative of the form present in the environmental medium of concern. The RfD and/or SF for each inorganic compound has been determined by the USEPA, based on the chemical form administered to the animal in the toxicological study. For example, the SF for beryllium was based on the carcinogenic effects of beryllium sulfate at intake levels of 0.16 to 5 ppm in the diet of rats, but the effects at these concentrations were not statistically significant (USEPA, 1987; SRC, 1991). It should be noted, however, that the USEPA (1987) has stated that this value may in fact be "overly conservative ... since negative results at much greater doses have been obtained in earlier studies."

5.2.2.2 Different Exposure Routes

Some of the inorganic and organic compounds present at this Site were administered by gavage in the animal studies that were used to establish the toxicity values. This may overestimate the risk or hazard because an absorbed dose (from a gavage-administered compound) can be one to two orders of magnitude higher than an orally administered dose, as indicated in animal studies on uranium absorption efficiency (SRC, 1989). The RfDs are usually assumed to be based on oral uptakes.

5.2.2.3 Additivity of Estimated Hazards and Risks

According to the USEPA guidelines for risk assessment of chemical mixtures (USEPA, 1986b), in the absence of specific toxicity data concerning the synergies, antagonisms, or potentiation of effects, the potential health hazards and risks associated with exposure to chemical mixtures are assumed to be additive. The assumption of additivity for the COPCs in the environmental media may overstate the actual total chronic toxicity because the major contributors may have entirely different disease mechanisms, and may also act on unassociated physiological systems.

5.2.2.4 Soil Matrix Effect

The bioavailability of chemicals in soil is generally diminished due to the matrix effect of the soil. This is particularly true for those inorganics which may be a component of the mineral structure of the soil and, thus, may not be available for uptake. The toxicity of inorganic compounds appear to correlate with their solubility in water. Consequently, the toxic metal that is solubilized in the moisture fraction of the soil will tend to be more bioavailable.

5.2.2.5 Bioavailability of Chemicals in Humans

In this BRA, the bioavailability or absorption efficiency in humans for the COPCs is assumed to be the same as in the respective animal model. The only exception is in the case where there is available information in the literature on the specific G.I. tract absorption rates in humans. It should, therefore, be noted that an assumption of equivalent absorption efficiency may actually overestimate the effective dose at the target organ.

5.2.2.6 Dose-Response Model

The assumptions utilized by the USEPA in the dose-response extrapolation model for carcinogens are very conservative and result in an exposure dose which is expected to occur only 5% of the time. That is, the determination of carcinogenic potency for COPCs is based on a 95% upperbound limit. The following assumptions relating to the model are also made:

- The extrapolation of data from high-dose exposure region in human and animal studies to low-dose exposure region of the general population;
- An interspecies (i.e., animal to man) correlation, based on body surface area;
- The extrapolation of data across exposure durations from acute or subacute to chronic cases; and
- The conditional probability that demonstrated cancer incidence in animal studies will also have similar occurrences in potentially exposed humans.

An example of USEPA conservatism is demonstrated in the derivation of the SF for arsenic. According to the USEPA Risk Assessment Forum (USEPA, 1988a), the use of an oral SF of 1.7 $(mg/kg/day)^{-1}$ to estimate potential cancer risk for arsenic may overestimate risk by as much as one order of magnitude. This overestimation is because the dose-response curve for the carcinogenicity of inorganic arsenic in humans may be nonlinear, and because the skin tumors associated with arsenic ingestion are most often curable. Thus, the estimates of cancer risk are not representative of increased mortality, but represent the increased incidence of a curable adverse condition (Westerman, 1991). It is also noteworthy that the oral SF for arsenic is derived from epidemiologic, rather than animal studies.

6.0 ESTIMATION OF EXPOSURE CONCENTRATIONS

For purposes of this BRA, the chemical analytical data presented in the RI report (Golder Associates, 1995) for the Site environmental media are used in the calculation of exposure point concentrations. The reasonable maximum exposure (RME) concentrations are used as exposure point concentrations for the Site in accordance with USEPA (1989a; 1989d; 1992b) guidance documents. The RME concentrations for a COPC is defined as either the highest detected concentration or the 95% upper confidence limit (95% UCL) on the arithmetic mean concentration, whichever is lower.

The 95% UCL is calculated by using the following equation from USEPA (1992b), which assumes a lognormal distribution of analytical data:

$$95\%UCL = e^{\left(\bar{y}+0.5s^2+\frac{sH_{1-\alpha}}{\sqrt{n-1}}\right)}$$

where:

UCL	=	upper confidence limit
e	=	the exponential function
$\bar{y}$	=	arithmetic mean of natural log-transformed data measurements
s^2	=	variance of natural log transformed data measurements
s	=	standard deviation of natural log transformed data measurements
H_{1m}	=	H-statistic value which depends on the degrees of freedom, m, and s^2 (Gilbert, 1987)
n	=	the number of samples

The application of the above equation to calculate 95% UCL is described by Gilbert (1987). These values are calculated using the H-statistic developed by Land and described by the USEPA in its guidance document (USEPA, 1992b).

The data assessment procedures used for the calculation of summary statistics, as described in Section 3.0, are also applied for the calculation of RMEs. For example, one-half of the quantitation limit (i.e., SQL or CRDL) is used in the calculation of 95% UCL values for organic and inorganic compounds, respectively, for non-detected data results.

6.1 Selection of Monitoring Wells

The USEPA "Region III Technical Guidance Manual" (USEPA, 1991b) recommends that groundwater exposure concentration be conservatively based on the results for the most impacted on-site well data in the area of potential exposure. This approach is based on the premise that a potential resident is unlikely to utilize water withdrawn from more than one groundwater source at any particular time. A cluster of nine monitoring wells, where hypothetical residential use may occur at the Berks Landfill Site, is chosen as representative of on-site groundwater concentrations. The rationale for well selection is discussed below.

It is important to note that there is no current downgradient potable use of on-site groundwater at the Berks Landfill. The monitoring wells sampled during the RI are evaluated to determine which wells (and corresponding groundwater quality data) should be used in the calculation of RME concentrations for the future hypothetical on-site residential groundwater use scenario. The selection of wells is based on their hydrogeologic position relative to potential future on-site receptors, borehole depth, screen interval, and groundwater flow and constituent transport patterns. All of the on-site monitoring wells are evaluated with respect to these criteria.

In order to select monitoring wells for use in calculating the RME for potential future on-site residential use, it is necessary to define the groundwater flow, constituent flow patterns, and ultimately, the exposure scenario. As discussed in the RI, groundwater flow at the Site is characterized by the presence of two flow systems: a shallow phreatic aquifer system, and a deeper, semi-confined flow system (see Section 3.6 of the RI report). Both groundwater systems are influenced by topography and flow in a north-northwest direction to the Cacoosing Creek tributary valley. The shallow and deep groundwater flow systems merge and flow to the west within the valley. The transport of constituents detected in groundwater at the Site tends to parallel the direction of groundwater flow, i.e., from the landfills northward to the Cacoosing Creek tributary valley and then westward within the valley.

The nearest on-site location, downgradient from the source area (landfills), where a resident could install a potable groundwater supply well would be at the Nein property. The Nein property generally encompasses the land north of the Cacoosing Creek tributary to Wheatfield Road, extending westward to the property boundary. However, while this future use scenario is possible, it is an unlikely exposure pathway because the residence was destroyed in a fire in November 1993; it is an undesirable piece of property for future development; and it has no public water supply or acceptable drinking water well (only a shallow hand-dug well exists). Therefore, this property may not be restored to residential use. Considering the groundwater flow and constituent transport patterns and the location of the Nein property, the potential future on-site exposure to groundwater is best represented by monitoring wells within the plume located along the Cacoosing Creek tributary valley (where the Nein property is located). Considering the above, the following monitoring wells are selected for calculating the RME concentrations for potential future on-site exposures: C-5, G-1, G-4, G-5, G-6, G-12, G-13, MP-14S, and MP-14D. Per USEPA (1991b) guidance, these wells are located within the flow area which may impact the Nein property located directly downgradient. Both shallow and deep wells are selected to represent groundwater from the depths typically encountered by residential wells in the area.

Future residential exposure to groundwater resulting from the installation of potable supply wells on the landfill and on the immediate adjacent landfill property is not a realistic future use scenario. As discussed in the USEPA guidance, "Presumptive Remedy for CERCLA Municipal Landfill Sites," (EPA 540-F-93-035), the Agency has determined that it is not appropriate or necessary to evaluate future residential use of landfill property. Therefore, monitoring wells considered to be representative of the landfill source (C-3S, C-3D, GR-19D, MP-3, MP-16, GR-18D, MP-18S, and MP-19S) are not selected for the future on-site residential groundwater use scenario.

The rationale for not selecting monitoring wells which are representative of the landfill source applies most clearly to monitoring wells C-3D and MP-18S. Based on the results of the RI, these two wells represent separate areas within the landfill source. Monitoring well MP-18S is located immediately downgradient from the landfill in the vicinity of the former landfill equipment maintenance shed. Monitoring wells, which are installed as close as 75 feet adjacent to MP-18S (GR-19D and MP-19S) and below MP-18S (GR-18D), exhibited only non-detectable to trace levels of VOCs. The position of MP-18S with respect to the landfill and former operations at the landfill, and the lack of detections of VOCs in immediately adjacent wells, suggest that MP-18S is representative of discrete impacts from the landfill or the equipment shed.

Monitoring well C-3D was initially installed as an open corehole which was subsequently retrofitted with a screened well casing during the RI. This previous design (open borehole) is believed to have allowed constituents within the landfill to impact the deeper portions of the well. As a result, well C-3D is not representative of the deeper groundwater in that area, but rather is representative of impact at a shallower depth. The discrete nature of the impact at well C-3D is substantiated by two factors. First, monitoring wells downgradient from C-3D exhibit similar constituents, but at concentrations that are orders of magnitude lower. Second, after C-3D had been retrofitted with a well screen and redeveloped (pumped), constituent concentrations decreased by approximately fifty percent (50%). These two factors strongly suggest that C-3D is representative of discrete potential impacts from the landfill.

On-site monitoring wells upgradient or sidegradient of the landfill source are not selected for use in calculating the RME because these wells are not hydrogeologically positioned within the area that may impact potential downgradient future on-site receptors. Furthermore, these wells generally exhibit the lowest groundwater constituent concentrations. The upgradient and sidegradient monitoring wells not included for the potential future on-site groundwater exposure scenario include: C-1, C-2, C-4D, C-4S, C-6D, C-6S, C-7D, C-7S, G-11, MD-2, MP-6, MP-15S, MP-15D, MP-17, and the auction house well.

Monitoring well MP-11 is not selected for use because the construction details and integrity of the well are in question. In addition, the former Nein residential well (hand-dug shallow well) is not selected because of its construction (i.e., the groundwater quality data obtained from the well during the RI would not be representative of the groundwater extracted from a properly installed potable supply well).

In summary, monitoring wells are selected for use in calculating the RME concentrations for potential future on-site groundwater exposures based upon (1) the wells' hydrogeologic position and constituent transport patterns; (2) whether the well is located within the landfill source area; and (3) the consideration of USEPA (1991b) policy of selecting wells that might impact the potential receptor. Based on these criteria, on-site wells which are selected for use in the BRA include: C-5, G-1, G-4, G-5, G-6, G-12, G-13, MP-14S, and MP-14D.

6.2 Site Air Investigation

Ambient air and passive gas vent sampling were conducted at the Site for establishing baseline conditions and for evaluating potential exposure to receptors. The database used in the air pathway analysis in the BRA includes both air quality and meteorological data. Air quality data were collected as part of the Phase 1B RI from various potential emission sources and exposure points around the Site. Air quality samples obtained during the Site investigation activities are mostly 8-hour and/or 24-hour time-weighted average (TWA) ambient air samples collected in Summa passivated canisters. The samples which were collected approximately one meter above ground level are considered to be adequately representative of baseline conditions at the Site. Ambient air samples were collected from the following areas:

- Between the leachate lagoons (one sample, 8-hour TWA);
- Approximately 125 meters downwind of the leachate lagoons (one sample daily for three days, 24-hour TWA);
- Leachate seep (one sample, 8-hour TWA); and,
- Downwind property boundary on the eastern landfill (one sample daily for three days, 24-hour TWA) and western landfill (one sample, 24-hour TWA).

In addition to the above TWA ambient air samples, grab samples of landfill gas from passive vents were also collected in Summa passivated canisters on the eastern landfill (two vents) and western landfill (one vent). The sampled gas vents were determined based upon field-screening data generated by using a portable gas chromatograph during the Phase 1A investigation.

Meteorological data (wind speed and direction, as presented on a wind rose diagram) for the Site region were obtained from the National Oceanic and Atmospheric Administration (NOAA). The Harrisburg, PA station, which is located approximately 35 miles west of the Site, is the nearest NOAA facility. Meteorological data for the Site (wind speed and direction) were measured at ground level using hand-held instruments during collection of air quality samples. These data have been presented in the RI report (Golder Associates, 1995).

The samples collected at the passive vents are used to evaluate potential exposures for workers and trespassers on-site, and residents living off-site. The samples collected at a point 125 meters downwind of the leachate lagoon water are used to evaluate current potential exposures at the Nein residence, and any potential future adjacent residences. These samples, in conjunction with those collected at the leachate seeps and lagoons, are used in the evaluation of potential exposures to on-site workers and trespassers. The samples collected at the downwind property boundary of the eastern and western landfills are used only in evaluating potential exposures to off-site residents.

6.3 Estimated RME Concentrations

6.3.1 Groundwater Medium

The RME concentrations for selected COPCs in groundwater are presented in Table 22. These concentrations are used in estimating exposures to potential receptors to background inorganic groundwater concentrations (current and future scenarios), off-site residents (current and future scenarios), and hypothetical on-site residents (future scenario only). The potential on-site resident is assumed to be exposed to a cluster of selected monitoring wells as stated above.

6.3.2 Surface Soil Medium

The RME concentrations for chemicals detected in background and on-site surface soils are presented in Table 23. These concentrations are used in estimating exposures to potential on-site trespassers (current and future scenarios) and maintenance workers (future scenario only).

6.3.3 Sediment Medium

The RME concentrations for chemicals detected in background and on-site sediment are presented in Table 24. These concentrations are used in estimating potential exposures to potential on-site trespassers (current and future scenarios).

6.3.4 Air Medium

The RME concentrations for volatile chemicals detected in passive vents are presented in Table 25. These concentrations are used in estimating exposures to potential off-site and on-site residents and on-site trespassers (current and future scenarios). Potential exposures to maintenance workers are evaluated under future exposure conditions only.

7.0 EXPOSURE ASSESSMENT

For purposes of this BRA, the potential exposure pathways for human receptors at the Site are identified in accordance with RAGS Vol. 1 (USEPA, 1989a). The identification of potential exposure pathways and exposed populations is based primarily on the RI report (Golder Associates, 1995), Site-specific conditions, local land-use patterns and ecology, and the activities of nearby residents. Potential exposures, under both current and hypothetical future land use of the study area, are also postulated. A current exposure scenario evaluates whether there is a potential health threat under existing conditions, while a future exposure scenario evaluates whether there is a potential health threat under hypothetical future conditions (based on current environmental point concentrations and no further remedial response actions). The identified exposure pathways and potential receptors used herein have been previously approved by USEPA Region III for use in this BRA (see Appendix A).

The following populations are identified as having the potential to be exposed to COPCs at the Site under current and/or future exposure scenarios:

- On-site residents at existing residential properties (future scenario only);
- Off-site residents in the vicinity of the Site (current and future scenarios);
- On-site trespassers (current and future scenarios); and,
- On-site maintenance workers (future scenario only).

7.1 Identification of Exposure Pathways

This section discusses the potential human exposure routes at the Site which are evaluated in this report. These are summarized in Table 26.

a. *Use of groundwater by an off-site resident under both current and future land use scenarios downgradient of the Site.*

   Potential exposure is assumed to be via ingestion of groundwater, dermal contact with groundwater, and inhalation of vapors from groundwater while showering.

b. *Use of groundwater downgradient of the landfills by an on-site resident at the Nein property under a hypothetical future use scenario.*

Because the Nein residence has currently burned down, and the shallow, hand dug well (which was not previously used for drinking) is inoperable, downgradient on-site groundwater is not currently being used for residential purposes. Although the Cass residential well is located on-site, it is hydrogeologically upgradient of the landfills.

Hypothetically, although quite unlikely, the undesireable Nein property could be redeveloped in the future and a well installed for potable use. It is important to bear in mind that this hypothetical exposure can be eliminated by deed restrictinos. However, for the purposes of this BRA, potential exposure is assumed to be via ingestion of groundwater, dermal contact with groundwater, and inhalation of vapors from groundwater while showering.

c. *Direct contact with surface soil by a child trespasser and a periodic maintenance worker at the Site.*

Potential exposure for the on-site child trespasser is assumed to be via incidental ingestion of, and dermal contact with soil. These pathways are assumed for both the current and future land use scenarios.

Potential exposure for an on-site future maintenance worker is assumed to be via incidental ingestion and dermal contact.

d. *Potential exposures to constituents in the surface water, sediments, leachate lagoon water, and leachate seeps.*

No COPCs were selected for surface water, leachate lagoon water, or leachate seep water (Tables 15 and 17). Consequently, exposure pathways for these media are not evaluated, and potential exposures will not be further considered in the BRA.

Potential exposure to chemical constituents in sediments is assumed to be via dermal contact during wading activities by a child trespasser. This pathway is assumed for both the current and future land use scenarios. Incidental ingestion of sediments is not considered a viable exposure pathway because of the shallow surface water depths and the small areas of potential exposure.

e. *Potential exposures to vapor phase chemicals from leachate lagoon water, leachate seep water and passive gas vents by an on-site child trespasser, on-site maintenance worker, on-site resident, and off-site resident in the vicinity of the landfill.*

The predicted air concentrations of vapor-phase chemicals from the passive vents will be determined by using appropriate USEPA-recommended exposure models (USEPA, 1988b) for both on-site and off-site receptors. These air concentrations will be conservatively used for evaluating potential exposures to the on-site child trespasser (current and future scenarios), on-site periodic maintenance worker (future scenario), on-site resident (future scenario), and off-site resident in the vicinity of the landfill (current and future scenarios). This procedure is very conservative because the ambient air sampling data collected during the RI to evaluate these scenarios did not identify any COPC in ambient air.

In view of the existing vegetative cover at both landfills and the relatively low detected constituent concentrations, the air suspension of particulate-phase chemicals in surface soil are not expected to be significant relative to other exposure pathways and will not be further considered in the BRA.

7.2 Uncertainties Associated with Exposure Assessment

Exposure assessment involves the determination of impacted environmental media at the Site; the identification of exposure pathways and populations; and the quantification of potential exposures. In developing the exposure scenarios, assumptions are made in the BRA that may introduce uncertainties into the exposure assessment. The exposure scenarios are based on assumptions that are made to overestimate rather than underestimate potential exposures. This is a conservative approach that is designed to be protective of public health and to compensate for uncertainties inherent in the exposure assessment. This approach also provides a margin of safety in estimating Site-specific risks.

Exposure parameters used in the BRA are based on USEPA guidance documents and Region III requirements, where applicable. Other exposure parameters, such as frequency of exposure and duration, are based on Site-specific conditions and professional judgments.. The assumption that constituent concentrations will remain constant over time, and that transport mechanisms are at steady-state conditions will likely result in an overestimation of exposure point concentrations. Chemicals are assumed to be uniformly distributed over the defined area, resulting in a uniform exposure level.

It is also assumed that the environmental fate mechanisms, such as biodegradation, attenuation, photo-oxidation, etc., will not have any effect on concentrations over time. In reality, however, natural processes will attenuate actual concentrations over time, especially in the context of lifetime exposure. This assumption tends to result in exposure levels that are likely higher than what would be expected in exposed populations especially for the hypothetical future use scenario. In summary, all of the uncertainties in this BRA will tend to over, and not underestimate the potential risks.

8.0 ESTIMATION OF HUMAN INTAKES

8.1 Potential Human Receptors

The receptors, exposure factors, and assumptions to be used in calculating chemical intakes, or, doses are presented below. The exposure factors and assumptions have also been previously approved by USEPA Region III for use in the BRA (see Appendix A).

8.1.1 Off-Site Resident

Potential exposures for the off-site resident are to chemicals detected in groundwater and vapor-phase chemicals present in passive landfill gas vents (current and future scenarios).

Consistent with USEPA guidance, the exposure duration for the off-site resident is assumed to be 30 years (USEPA, 1989a; 1989c). This value approximates the 90th percentile value for length of time a homeowner will live at one residence. However, the majority of the U.S. population lives at one residence for less than 30 years, with an average length of residence at one home of nine years (USEPA, 1989c).

8.1.2 On-Site Resident

Potential exposures for the on-site resident are to chemicals detected in groundwater and vapor phase chemicals present in passive gas vents (future scenario only).

Consistent with USEPA guidance, the exposure duration for the on-site resident is assumed to be 30 years (USEPA, 1989a; 1989c). Similar to the off-site resident, this duration approximates the 90th percentile value for length of time a homeowner will live at one residence. The majority of the U.S. population lives at one residence for less than 30 years, with an average length of residence at one home of nine years (USEPA, 1989c).

8.1.3 On-Site Trespasser

Potential exposures for the on-site trespasser are to chemicals present in surface soil, sediment, and air at the Site (current and future scenarios). The type of population considered to trespass at Berks Landfill are older children and/or teenagers. Therefore, for estimating exposures for the trespasser, the potentially exposed population is assumed to be school-age children over a nine-year period. The potential estimates of chemical intake, or dose, have been specifically developed using the physiologic parameters for a young teenager as being representative of this age group (more sensitive population).

It is unlikely that area residents would have reason to regularly gain access to the Site because of the chain-link security fence that will serve to limit accessibility. In addition, the rural nature of the Site and limited road or public access also limits the Site's accessibility. Nevertheless, USEPA Region III has required Golder Associates to conservatively assume that a child trespasser would visit areas of the Site 50 days per year, or approximately once a week.

8.1.4 On-Site Worker

Potential exposures for the on-site worker are to chemicals present in surface soil and vapor-phase chemicals found in passive vents that may be potentially associated with periodic maintenance activities in the future.

Future maintenance activities at the Site are expected to include periodic inspection and/or prevention and repair maintenance of surface water drainage systems, leachate management system, cover systems, groundwater monitoring wells and Site security by an adult worker. Typical operation and maintenance plans for closed municipal solid waste landfill would include maintenance activities being conducted at the Site approximately 24 days per year or twice per month (on average). This frequency is based on Golder Associates' professional judgment and experience with the operation and maintenance of closed municipal solid waste landfills. Therefore, future exposures to maintenance workers at the Site are expected to occur 24 days per year or less

8.2 Groundwater Exposure Factors

8.2.1 Ingestion of Groundwater

Ingestion of groundwater represents a potential exposure route under current and future use conditions for off-site residents and future use conditions for the on-site residents. Both assume the residents obtain their potable water supply from private wells. The factors that must be considered when estimating potential exposure via this pathway include: (1) the chemical concentration in groundwater; (2) the rate of drinking water ingestion; and (3) the frequency and duration of exposure. Exposure of a residential population to known or suspected carcinogenic and noncarcinogenic COPCs via drinking water ingestion is calculated using the equation in Table 27. The basis for the exposure factors and assumptions that are used to model this pathway are also presented in Table 27.

8.2.2 Dermal Contact (Showering) With Groundwater

Dermal contact with groundwater while showering represents a potential exposure route for on-site residents (future use conditions) and off-site residents (current and future use conditions) who obtain their domestic water supply from a private well. The following factors must be considered when estimating exposure via this pathway: (1) the chemical concentration in groundwater; (2) the amount of exposed skin surface area; (3) the efficiency of dermal absorption of the chemicals; and (4) the extent and duration of exposure. Exposure of a residential population to known or suspected carcinogenic and noncarcinogenic COPCs via dermal absorption of groundwater while showering is calculated using the equation in Table 28. The basis for the exposure factors and assumptions that are used to model this pathway are also presented in Table 28.

8.2.3 Inhalation of Vapors (Showering)

Inhalation of organic chemicals present in groundwater which potentially volatilize during showering activities represents a potential exposure route for on-site residents (future use conditions) and off-site residents (current and future use conditions). The following factors must be considered when estimating exposure via this pathway: (1) the chemical concentration in air, based on volatilization of groundwater conditions exiting the shower head; (2) the inhalation rate; and (3) the length, frequency and duration of exposure.

An integrated household exposure model developed by Foster and Chrostowski (1986) is used in determining volatile vapor emissions as a result of showering activities. The shower model is used to estimate a dose, expressed in mg/kg per shower, for a 70 kg individual inhaling volatilized organic constituents while showering. In modeling the transfer of a chemical through an inhalation pathway, it is necessary to quantify the chemical transfer rates from water to air and from air to humans. It is assumed that the water-to-air process follows the two-film gas-liquid mass transfer theory. Assumptions are also required for shower water temperature, ventilation rate, shower droplet diameter, and duration and frequency of showering (see Appendix C for details). As dermal exposure is also considered during showering, it is possible that the use of the showering model may overestimate exposure because chemicals assumed to be absorbed through the skin are not subtracted from the total available mass during showering activities.

Exposure of the residential population to known or suspected carcinogenic and noncarcinogenic COPCs via inhalation of volatile organic chemicals while showering is calculated using the equation in Table 29. The basis for the exposure factors and assumptions that are used to model this pathway are also presented in Table 29.

8.3 Soil and Sediment Exposure Factors

8.3.1 Ingestion of Soil

Exposure to COPCs is assumed to occur through incidental ingestion of soil by an on-site child trespasser and by future on-site workers performing periodic maintenance activities. The factors that must be considered when estimating exposure via this pathway include: (1) the chemical concentrations in soil; (2) the rate of soil ingestion; (3) the fraction of soil ingested that comes from an affected source; (4) the bioavailability of the chemical adsorbed to soil, if known; and (5) the period of time over which soil ingestion will occur.

Potential exposures of trespassers and on-site workers to known or suspected carcinogenic and noncarcinogenic COPCs via soil ingestion are calculated using the equation in Table 30. The basis for the exposure factors and assumptions that are used to model this pathway are also presented in Table 30.

Based on USEPA (1991a) guidance, the soil ingestion rate for the on-site trespasser is assumed to be 100 mg/day. An individual who trespasses at Berks Landfill, however, would most likely spend only a limited amount of time on-site (i.e., no more than an hour or two and probably much less time). Therefore, the full daily amount of ingested soil (100 mg) would not be expected to come entirely from the Site. In order to provide a conservative estimate of intake, however, it is assumed in this assessment that the entire amount of daily soil ingestion would be from the Site during each trespass event.

In the case of an on-site worker who periodically performs maintenance activities in the future, a soil ingestion rate of 50 mg/day has been assumed based on guidance in USEPA (1991a).

8.3.2 Dermal Contact With Soil and Sediment

Dermal contact with surface soil and sediment represents a potential route of exposure. However, as noted by the USEPA (1992a), dose and risk estimates based on the available models for estimating dermal uptake of chemical compounds in soil/sediment are considered highly uncertain. It is noteworthy that experimental data on dermal absorption from soil, relevant to quantitative risk assessment, are available for only a limited number of compounds, none of which is among the COPCs detected in either soil or sediment at the Site. Therefore, as recommended in USEPA (1992a), quantitative estimation of exposure via this pathway is not performed in the BRA for the COPCs in these media.

In addition, because potential exposure via incidental ingestion of soil has been evaluated for the media in question, and because prior experience indicates that exposures associated with incidental soil ingestion will be substantially higher than dermal contact, it is, therefore, unlikely that total exposures and risks will be underestimated.

8.4 Air Exposure Factors

Inhalation of Airborne Chemicals

Potential on-site workers and trespassers are assumed to be exposed to volatile organic chemicals from passive landfill gas vents under both current and future exposure conditions. The RME concentrations determined from passive landfill gas vents presented in Tables 18 and 25 were used to calculate an emission rate as described in Appendix D. The calculated emission rate was then used in the box and dispersion models described in Appendix D to obtain the modeled VOC concentrations. Table D-1 presents the calculated emission rates and the modeled concentrations for both models. These modeled VOC concentrations were then used to estimate risk in Appendix E.

Off-site residents in the vicinity of the landfill are also assumed to be exposed to COPCs from passive landfill gas vents during outdoor activities. Such activities may include home maintenance, gardening, etc., as suggested in the Exposure Factors Handbook (USEPA, 1989c). Both current and future exposure scenarios are considered viable for this pathway in the BRA. It should be noted that, as discussed in Section 6.2, fence-line air monitoring was conducted at the Site for the evaluation of off-site residents. However, none of the detected chemicals in the analyzed samples exceeded USEPA (1994a) risk-based screening concentrations.

The exposure factors that must be considered when estimating exposure via this pathway include: (1) the measured chemical concentrations in ambient air (based on volatilization from leachate lagoon water and leachate seep water) or the modeled concentrations from passive gas vents; (2) the inhalation rate; and (3) the length, frequency, and duration of exposure.

The emission rate methodology for "Landfills with Internal Gas Generation" presented in USEPA (1988b) is used to estimate the volatilization of chemicals at the Berks Landfill. Two air models are used to determine volatilization and migration of chemicals at the Site. These include a box model to estimate potential on-site exposures and a Gaussian dispersion plume model to estimate potential on-site and off-site exposures. Both models rely on air emission rates estimated from given chemical concentrations, gas velocity, and landfill dimensions. Inputs to the box model include atmospheric mixing height, average wind speed, and estimated length of impacted area. The Gaussian plume dispersion model conservatively assumes that the wind direction is constantly toward the receptor 100 percent of the time. This model also assumes a ground level source with no effective plume rise. The Gaussian dispersion model is especially conservative and tends to overestimate chemical concentrations at the point of exposure. Details of both exposure models are provided in Appendix D of this report.

The exposure of the off-site residential, on-site trespasser, or on-site maintenance worker populations to known or suspected COPCs via inhalation of volatile organic chemicals is calculated by using the equation in Table 31. The basis for the exposure factors and assumptions that are used to model this pathway are also presented in Table 31. It should be noted that, as discussed in Section 6.2, on-site ambient air monitoring samples including locations at leachate seep and leachate lagoons were evaluated for on-site trespassers and periodic maintenance workers. However, none of the detected chemicals in these samples exceeded the USEPA (1994a) risk-based screening concentrations.

9.0 RISK CHARACTERIZATION

The potential health hazards and risks associated with both current and future potential exposures to affected environmental media at the Berks Landfill Site are characterized in this section. The information from the toxicity assessment and the exposure assessment is integrated to form the basis for the characterization of both carcinogenic and noncarcinogenic potential health risks.

The methodology for deriving quantitative cancer risk estimates is presented below in Section 9.1. The potential health hazards for the current and hypothetical future use scenarios addressed in this risk assessment are presented in Section 9.2. As discussed in Section 8, each scenario was modeled for the RME condition. The RME is used to estimate a conservative exposure case, according to USEPA (1989a) guidelines.

It should be emphasized that the risk values estimated in this assessment are not actual risks. Rather, the risk estimates are based on multiple conservative assumptions and, thus, represent upper bound potential risks. The numerical risk estimates that are presented in this section must be interpreted in the context of the uncertainties and assumptions associated with each component of the risk assessment process. The major uncertainties and assumptions associated with this risk assessment are discussed in Section 10.0, Uncertainty Analysis.

9.1 Estimation of Cancer Risks

The numerical estimate for an excess lifetime cancer risk resulting from the modeling exposure to a specific carcinogenic COPC can be calculated by multiplying the chronic daily intake (CDI) or dose by the SF, as follows:

$$\textit{Cancer Risk} = \textit{CDI} \times \textit{SF}$$

where:

Cancer Risk	=	lifetime probability of developing cancer following exposure to a COPC
CDI	=	chronic daily intake (mg/kg-day)
SF	=	cancer slope factor $(\text{mg/kg-day})^{-1}$

This linear equation is only valid at low risk levels (i.e., below estimated risks of 1E-02). For carcinogens, intake values represent daily values averaged over a lifetime of exposure assumed to be 70 years. Slope factors for chemical carcinogens generally represent a 95% upper bound limit of the slope of the dose-response curve. Thus, one can be reasonably confident that the actual risk is likely to be less than predicted.

In order to evaluate the significance of Site-related cancer risks, the calculated estimates are compared with target risk levels. Cancer risk is stated in terms of upperbound excess cancer cases attributed to exposure to the suspect carcinogen at the estimated dose. Thus, a 1×10^{-6} cancer risk would be equivalent to one additional cancer case expected in an exposed population of one million over that expected in an unexposed population. In a study reported by Crouch et al. (1987), the general population faces a lifetime risk of one in three of developing any kind of cancer due to any reason (e.g., dietary habits, smoking, radiation, occupational exposure, etc.).

According to the USEPA, it is generally acceptable if the upperbound incremental cancer risk for an individual, resulting from potential exposure to hazardous chemical constituents, is between 10^{-6} and 10^{-4} (National Oil and Hazardous Substances Pollution Contingency Plan [NCP] 40 CFR Part 300 et seq).

In cases of multiple chemical exposures, regulatory agencies also assume cancer risks to be additive (USEPA, 1986a; 1989a). Consistent with USEPA guidelines, the risk estimates presented in this section are the sums of individual risk estimates for all COPCs evaluated in this assessment. This risk summation process assumes an independence of action for each of the chemicals of interest because risks for specific chemicals represent individual probabilities of developing a cancer. It has not been demonstrated, however, that different cancers have the same risk factors, or that different cancer-causing agents have the same mechanisms of action. Therefore, the actual risks associated with multiple chemical exposures could differ from added risks.

9.2 Estimation of Noncarcinogenic Effects

Potential human health hazards associated with exposure to noncarcinogenic substances, or carcinogenic substances with systemic toxicities other than cancer, are evaluated separately from cancer risks. The daily intake over a specified time (e.g., lifetime or some shorter time period) is compared to an RfD for a similar period (e.g., chronic or subchronic RfD) to determine a ratio referred to as a hazard quotient (HQ). The equation for calculating HQ is:

$$HQ = \frac{CDI}{RfD}$$

where:

HQ	=	Hazard Quotient
CDI	=	Chronic daily intake (mg/kg-day)
RfD	=	Reference dose (mg/kg-day)

The hazard quotients for individual chemicals may be added for any single exposure pathway to estimate the occurrence and severity of toxic effects resulting from exposure to multiple constituents. The sum of the hazard quotients for individual chemical constituents for a given exposure pathway is referred to as Hazard Index (HI).

The HI approach assumes that multiple sub-threshold (below the RfD) exposures could result in an adverse effect and that a reasonable criterion for evaluating the potential for adverse effects is the sum of the hazard quotients. If the HI is less than one (1) or unity, no adverse health effects are expected from potential exposure to COPCs. If the HI is greater than one, there is an increased potential for adverse effects under the assumed exposure scenarios. An HI greater than one, however, does not necessarily indicate that the exposure would harm individuals. It should be noted that this methodology is most properly applied to substances that induce the same effect(s) on the same target organs (USEPA, 1986a; 1989a). Consequently, application of the HI methodology to a mixture of substances that are not expected to induce the same effect(s) on the same organs would likely overestimate the potential for adverse noncarcinogenic health hazards. Therefore, if the HI is greater than one, it may be appropriate to further examine the specific health effects of each constituent contributing to the HI.

9.3 Cancer Risks and Hazard Indices

The potential lifetime excess cancer risk estimates and the hazard indices for the COPCs, under each of the scenarios considered in this assessment, are summarized in Tables 32 to 36. Risk estimates for each of the populations that could potentially be exposed to COPCs in the exposure scenarios developed for the Site are discussed in the following sections. As discussed previously, many of the exposure scenarios developed in this risk assessment are conservative and/or are unlikely to occur. The spreadsheets used in calculating potential cancer risks and hazard quotients for each of the COPCs for the modeled pathways are presented in Appendix E of this report.

9.3.1 Background Risks and Hazards

Groundwater

Potential risks and hazards from the exposure to background-related inorganic chemicals are estimated for potentially exposed human receptors to groundwater under both current and future scenarios. Specifically, hypothetical exposure via ingestion of groundwater is evaluated for potential adult and child receptors. As indicated in Table 32, a cancer risk of 3×10^{-4} is postulated for the potential ingestion of background groundwater. This risk estimate is entirely attributable to the presence of arsenic and beryllium in groundwater. The estimated HI for the potential ingestion of background groundwater is 14 (Table 32). Manganese concentrations in groundwater represent the major contributor to this estimate (see Appendix E for chemical-specific risk estimates). However, because manganese is considered an essential nutrient, the true risk of adverse health effects is uncertain.

Surface Soil and Sediment

Potential risks are estimated for a child trespasser for hypothetical exposure to beryllium in background surface soil under both current and future conditions. The estimated potential cancer risk for incidental ingestion of beryllium in background soil is 2×10^{-7} and the HI is estimated to be 7×10^{-5} (Table 32).

Dermal contact with surface soil and sediment represents a potential route of exposure. However, as noted by USEPA (1992a), dose and risk estimates based on the available models for estimating dermal uptake of chemical compounds in soil/sediment are considered highly uncertain. In addition, quantitative risk estimates are determined for only a limited number of compounds, none of which is among the COPCs present in soil or sediment at this Site. Therefore, as recommended by USEPA, potential risks are not estimated for this pathway for the COPCs detected in soil or sediment.

Cumulative Risks and Hazards

The total lifetime excess cancer risk from combined potential exposures to the background groundwater and surface soil pathways is 3×10^{-4}. The total HI value for the combination of these pathways is 14 (Table 32). The potential ingestion of arsenic, beryllium, and manganese in affected background groundwater contributes most of the estimated total excess cancer risk and noncancer hazard for the potential receptors.

9.3.2 Off-Site Residential Risks and Hazards

Groundwater

In the case of the current and hypothetical future exposures to inorganic and organic chemicals in residential wells located downgradient of the Site, potential cancer risks and noncancer hazards are estimated for off-site residents. Specifically, potential exposures via ingestion, dermal contact, and inhalation of volatiles while showering or bathing are evaluated.

As indicated in Table 33, the potential cancer risk for hypothetical exposure to off-site groundwater is mainly attributable to potential ingestion of arsenic. An estimated cancer risk of 2×10^{-4} is postulated for potential ingestion of affected groundwater by off-site residents which is less than the estimated risk due to exposures to background groundwater. However, as indicated by the chemical-specific risk estimates presented in Appendix E, the infrequent and detected low concentrations of organic constituents in residential well water resulted in an estimated potential excess cancer risk of 2×10^{-6}, which is well within the USEPA acceptable risk range.

Air

In the case of potential exposure via inhalation of vapor-phase chemicals from passive gas vents by an off-site resident the estimated potential cancer risk is 2×10^{-5}, while the HI is 0.7 (Table 33), under both current and future exposure conditions. The estimated cancer risk for potential inhalation of vapor-phase chemicals is due primarily to the presence of vinyl chloride in passive landfill gas vents while the estimated hazard index is due primarily to the presence of hydrogen sulfide in passive landfill gas vents (see Appendix E for chemical-specific risk estimates).

Cumulative Risks and Hazards

For an off-site resident, the total lifetime excess cancer risk from combined potential exposures to groundwater and air pathways is 2×10^{-4}. The total HI value for combined pathways associated with these media exceeds 1 (Table 33). The potential ingestion of arsenic in groundwater contributes virtually all of the estimated total excess cancer risk for the off-site resident. It should also be particularly noted that arsenic is the primary contributor to excess cancer risk for hypothetical exposure to background groundwater. Noncancer risk for the off-site resident is due primarily to ingestion of arsenic in groundwater and exposure to hydrogen sulfide gas from passive landfill vents. Because arsenic and hydrogen sulfide have different toxic endpoints and target organs, the addition of the individual HIs is not appropriate, as recommended by USEPA (1989a). Neither HI individually exceeds 1.

9.3.3 On-Site Trespasser Risks and Hazards

Surface Soil and Sediment

Potential risks and hazards from exposure to on-site surface soil are estimated for a child trespasser under both current and future exposure scenarios. As presented in Table 34, a cancer risk of 1×10^{-6} is estimated for the potential incidental ingestion of surface soil. This estimate is primarily related to the presence of arsenic and beryllium in soils (see Appendix E for chemical-specific risk estimates). The estimated HI for the potential ingestion of surface soil by a trespasser is 0.01 (Table 34).

Dermal contact with surface soil and sediment represents a potential route of exposure. However, dose and risk estimates, based on the available models for estimating dermal uptake of chemical compounds in soil/sediment, are considered highly uncertain for most constituents and are only determined for a limited number of compounds. Therefore, for the detected COPCs in these media, potential risks are not estimated for this pathway, as recommended by USEPA.

Air

Potential risks and hazards are estimated for an on-site trespasser who is potentially exposed to volatiles from passive gas vents under both current and future exposure scenarios. The estimated potential cancer risk via inhalation of volatiles is 3×10^{-8}, while the HI is estimated to be 4×10^{-3} (Table 34).

Cumulative Risks and Hazards

The total lifetime excess cancer risk for a child trespasser from combined exposures to surface soil and air pathways is 1×10^{-6} The total HI value from combined pathways associated with these media is 0.01 (Table 34). As stated above, it is the potential ingestion of arsenic and beryllium in surface soil which accounts for all estimated total cancer risk for the on-site trespasser. Once again, arsenic and beryllium are the primary contributors to the background soil risk estimates.

9.3.4 On-Site Worker Risks and Hazards

Surface Soil

The cancer risk and HI estimates for potential exposure to surface soil by future on-site maintenance workers are based on incidental ingestion of chemical constituents. As indicated in Table 35, the estimated cancer risk for this exposure scenario is 5×10^{-7}, while the estimated HI is 0.002. Chemical-specific risk estimates are presented in Appendix E.

Dermal contact with surface soil and sediment represents a potential route of exposure. However, dose and risk estimates, based on the available models for estimating dermal uptake of chemical compounds in soil/sediment, are considered highly uncertain for most constituents and are only determined for a limited number of compounds. Therefore, for the detected COPCs in these media, potential risks are not estimated for this pathway, as recommended by USEPA.

Air

Potential risks and hazards are estimated for a future on-site maintenance worker who is potentially exposed to volatiles present in passive gas vents via inhalation. The estimated potential cancer risk is 1×10^{-7}, while the HI is estimated at 5×10^{-3} (Table 35).

Cumulative Risks and Hazards

The total lifetime excess cancer risk from combined soil and air exposure pathways is 6×10^{-7}. The total HI value for these combined exposure pathways is 0.007 (Table 35). Most of the estimated total cancer risk for the on-site worker is attributed to the incidental ingestion of detected chemicals in surface soil.

9.3.5 On-Site Residential Risks and Hazards

Groundwater

In the case of future hypothetical exposure to chemicals in selected on-site monitoring wells, potential cancer risks and noncancer hazards are estimated. Specifically, potential exposures via ingestion, dermal contact, and inhalation of vapors while showering or bathing are evaluated. As indicated in Table 36, an estimated cancer risk of 1×10^{-3} is postulated for the potential ingestion of groundwater by future on-site residents. The estimated cancer risk for dermal exposure is 4×10^{-6} and a cancer risk of 2×10^{-4} is estimated for the inhalation of vapors while showering. The potential excess cancer risk for hypothetical exposure to on-site groundwater is mainly attributable to ingestion of vinyl chloride, although the estimated risk from the potential inhalation of this compound's vapors while showering is also significant. As indicated in Table 36, the estimated HI for the potential ingestion of affected groundwater by future on-site residents is 50. Manganese concentrations in groundwater are primarily responsible for this value (see Appendix E for chemical-specific risk estimates).

Air

In the case of hypothetical exposure via inhalation of volatiles from passive gas vents by a future on-site resident, the estimated cancer risk is 1×10^{-7}, while the HI is 4×10^{-3} (Table 36).

Cumulative Risks and Hazards

For a future on-site resident, the total lifetime excess cancer risk from combined hypothetical exposures to groundwater and air pathways is 1×10^{-3}. The total HI value for the combined pathways is 50 (Table 36). The potential ingestion of vinyl chloride in groundwater, and the inhalation of volatiles while showering contribute most of the estimated total cancer risk. The potential ingestion of manganese is primarily responsible for the estimated total noncancer hazard for the hypothetical future on-site resident.

9.4 Evaluation of Exposure to Lead

The USEPA does not use an RfD or SF approach for evaluating potential risks associated with lead exposure. Instead, the USEPA Integrated Exposure/Uptake/Biokinetic (IEUBK) model (USEPA, 1994d) is used to predict the likelihood of children chronically exposed to lead through air, water, soil, housedust, and other sources exceeding a particular blood lead concentration (usually 10 µg/dL). The latest version of this model, 0.99d, is used here.

The IEUBK model is generally used as a decision tool in contaminated soil scenarios. As such, it is used to evaluate the likelihood of children within a particular residence or neighborhood exceeding the blood lead criterion. The inputs to the model should reflect the residence-specific arithmetic average lead concentrations to which children could be exposed, as well as averages of exposure parameters. It is inappropriate to use RME or worst-case values for inputs in the IEUBK model, because the output of the model should reflect the predicted geometric mean (GM) of population blood lead levels, along with as the predicted variability in these levels, as indicated by the geometric standard deviation (GSD) (USEPA, 1994).

Since specific information is not available regarding exposure scenarios, the approach taken here evaluates an average future receptor's predicted lead exposure, given no remedial action, at the Berks Landfill site. The majority of the inputs, including exposure parameters, were IEUBK v. 0.99d model default values, and are not listed here. Site-specific information was not available for air and dietary concentrations; therefore IEUBK default values were assumed. The only changes from model default assumptions were values for concentration of lead in soil, housedust, and groundwater:

- Site-wide arithmetic average for soil lead concentration: 14.6 µg/kg.
- Average housedust lead concentration assumed to equal average soil lead concentration: 14.6 µg/kg.
- Arithmetic average groundwater lead level from wells C-5, G-1, G-4, G-5, G-6, G-12, G-13, MP-14S, and MP-14D (as discussed in Section 4.2.1) :15.3 µg/L.

The USEPA method of determining lead risks is to evaluate the likelihood of children exceeding the 10 µg/dL criterion. This likelihood is given by the percentile of the predicted blood lead concentration distribution that reflects this criterion. Table 37 and Appendix F are the IEUBK model output for the inputs as noted above. The likelihood of an average child aged 0-84 months exceeding 10 µg/dL blood lead at this site under current conditions is less than 1% (0.17th percentile) (see Table 37). Some age specific risks may be higher; the same likelihood for an average child aged 12-24 months (the highest-exposure temporal category) is still less than 1% (0.35th percentile) (see Table 37). The decision-point for remedial action based on lead is a greater than 10% chance that a child will exceed 10 µg/dL blood lead (EPA 1994). The likelihood of elevated blood lead concentrations under the scenario evaluated is less than the USEPA decision-point; therefore, lead will not be considered further in this risk assessment.

10.0 UNCERTAINTY ANALYSIS

Some of the uncertainties and limitations of the quantitative BRA, as related to toxicity and exposure assessments, have been previously identified and discussed in Sections 5.2.2 and 7.2, respectively. However, a more detailed discussion of pathway-specific uncertainties associated with the assessment of potential current and future risks at the Berks Landfill Site is presented below.

Health risk estimation quantitatively defines the general magnitude of human health risks, the precision of which is limited by the size and quality of the database and other input parameters. Consequently, the results of the analyses in this report are only as accurate as the available information, especially with respect to constituent toxicity and exposure parameters. Uncertainties may arise because of the general need to make a relatively large number of assumptions and inferences to complete each of the involved steps. Some of these assumptions and inferences are needed to compensate for lack of toxicological data on the chemical of interest, or for gaps in the information available to estimate potential exposures.

Toward this end, the approach taken in this assessment to offset uncertainties is biased toward health-protective assumptions that may exaggerate potential risks. For example, the exposure scenarios are based on assumptions that are made to overestimate rather than underestimate exposures. As noted above, the average length of time an individual spends in one home is 9 years; however, 30 years has been used in this risk assessment for the off-site residential exposure in the vicinity of the Site.

A conservative approach has been taken to estimate the exposure levels and their duration, and to characterize the hazards associated with the chemical constituents found in groundwater, surface soil, and air at the Site. Consequently, the health risk estimates derived in this BRA are magnified, with each step building on the previous one. This approach is designed to compensate for inherent uncertainties, and also provides a margin of safety in the use of risk assessment results for making risk management decisions.

The contributions of cancer and noncancer risks due to "background" sources are an area of great uncertainty in evaluating potential risks associated with the COPCs at the Berks Landfill. For example, three of the most important inorganic chemicals in off-site residential and on-site (downgradient) monitoring wells which appear at similar concentrations in background (upgradient) locations are arsenic, beryllium, and manganese. In particular, the potential lifetime cancer risks associated with exposure to the 95% UCL concentrations of arsenic and beryllium in background groundwater exceed the estimated risks for both off-site residential and on-site groundwater. The naturally occurring minerals in soil and bedrock and the acidic nature of the groundwater (upgradient and downgradient) appears to be responsible for the elevated concentrations of these chemicals in groundwater. Consequently, potential risk posed by ingestion of arsenic, beryllium, and manganese in groundwater may be attributed to groundwater conditions which exist upgradient of, or are otherwise unrelated to the Berks Landfill.

Estimated potential cancer risks, due to potential exposure to arsenic and vinyl chloride in groundwater, represent the highest potential lifetime cancer risks of any of the COPCs at the Site. The potential arsenic chronic daily intake estimated for the off-site residential population is 5.64E-05 mg/kg/day or 3.9 µg/day. The potential arsenic intake estimated for the future on-site exposed population is 2.19E-04 mg/kg/day or 15.3 µg/day. By comparison, the current USEPA drinking water standard of 50 µg/L or 7.1E-04 mg/kg/day is several fold higher than the estimated chronic daily intakes in the BRA.

There is little doubt that excessive intake of arsenic may lead to the development of skin cancer; however, the cancer risks posed by the intake of arsenic of less than 200 to 250 µg/day are not well understood. In an evaluation of human toxicokinetic and metabolic data concerning arsenic, Marcus and Rispin (1988) concluded that there is a practical threshold of arsenic intake at which skin cancer is unlikely to be manifested. Because the body efficiently metabolizes and excretes arsenic from 200 to 250 µg/day, this threshold should equally apply to arsenic-induced skin cancer (Marcus and Rispin, 1988). Studies of affected human populations also indicated no increased risk of skin cancer at arsenic intakes less than 400 µg/day (Stöhrer, 1991).

Estimated arsenic intakes from groundwater at the Berks Landfill for the reasonable maximum exposure scenario (i.e., 3.9 and 15.3 µg/day) are well below 200 or 400 µg/day, thus, arsenic in groundwater at the Site found at these concentrations is not likely to result in an increased risk of skin cancer based on the information identified above.. However, arsenic at the levels reported in groundwater may pose a significant risk as calculated using the current slope factors which do not include a threshold consideration. Equivalent levels and risks also occur in background groundwater.

The USEPA has concluded that human epidemiological studies of vinyl chloride inhalation and the occurrence of tumors in various animal tissues, following inhalation and oral exposures, constitute strong evidence of vinyl chloride carcinogenicity (SRC, 1989a). However, some of these studies indicated that the types of elicited tumors may be dose-related; thereby, suggesting that there may be a threshold dose below which there are no carcinogenic effects. Using vinyl chloride epidemiological data, and the USEPA-derived upperbound cancer SF of 1.7, Hawkins (1991) found that the standard risk assessment model for vinyl chloride predicted that up to 7,500 workers out of 10,000 exposed at historical doses would be expected to develop cancer. In the epidemiological study results, however, less than 10 out of 10,000 workers were actually shown to have contracted cancer; a difference of about three orders of magnitude. The above study, thus, suggests that the use of the vinyl chloride toxicity factor for incidence of carcinogenicity may overestimate risk. In addition, the slope factor for vinyl chloride is reported in the USEPA Health Effects Assessment Summary Tables (HEAST) as "under review, number subject to change" (USEPA, 1994c). Therefore, there is substantial uncertainty associated with the use of this slope factor for vinyl chloride in risk calculations.

In addition, because manganese is considered an essential nutrient, uncertainty may be associated with the noncarcinogenic risk estimates, possibly overestimating the estimated hazard indices for on-site groundwater.

In most risk assessments, chemicals are present that cannot be included in the quantitative risk assessment because little or no information on the toxicity of the chemicals are available. In the current assessment, the only COPCs for which there are no available carcinogenic and/or noncarcinogenic toxicity values are: 4-chloro-3-methyl phenol (leachate), 1,2-dichloro-1,1,2,2-tetrafluoroethane, and 4-ethyl toluene (air). However, because these compounds are only present in their respective environmental media at low concentrations, they are not expected to pose significant health risks at the Site relative to other more toxic compounds. Finally, it is very unlikely that failure to consider these substances in the quantitative risk assessment would result in an underestimation of total risk for any modeled exposed populations.

In summary, due to the conservatism associated with calculation of chemical exposures for both current and future hypothetical receptors, and the conservatism associated with the USEPA methodology for assessing noncarcinogenic and carcinogenic health risks, it is very likely that the estimates calculated in this BRA will exaggerate the potential risks associated with the chemicals of interest at the Berks Landfill.

11.0 DISCUSSION AND CONCLUSIONS

A discussion of the risk estimates from potential exposure by identified populations to chemicals of interest at Berks Landfill is presented in this section. Also presented in this section are conclusions based on the results of the risk assessment. The BRA for the Site evaluated the potential risks to human health under potential current and future exposure conditions. The risk assessment involves the use of numerous assumptions, each of which has various degrees of inherent uncertainty. Because of the uncertainties and conservative nature of the assumptions used, the estimate of risks may be quite different (i.e., exaggerated) from the actual risks posed by the Site.

An evaluation of the cancer risk estimates from exposure to COPCs for each of the modeled populations in this BRA indicates that the total excess cancer risk and HI estimates for a hypothetical receptor to background groundwater and background surface soil chemical concentrations, under current and future exposure scenarios, exceed USEPA recommended upperbound cancer risk range of 10^{-4} to 10^{-6} for carcinogens and 1 for noncarcinogens. Specifically, the estimated total excess cancet risk is 3×10^{-4} and the total HI is 14 for potential exposure to background groundwater concentrations only. The cancer risk estimate, as indicated in Table 32, is attributable to detected concentrations of arsenic and beryllium, while the HI is attributable to manganese concentrations in background groundwater at the Site.

Under hypothetical current and future scenarios, the total lifetime excess cancer risk of 2×10^{-4} for an off-site resident slightly exceeds the 10^{-4} to 10^{-6} range of cancer risks considered acceptable by the USEPA. The cancer risk estimate, as indicated in Table 33, is attributable to detected concentrations of arsenic in groundwater. The total estimated HI for an off-site resident slightly exceeds the Agency recommended criterion of 1. The HI estimate is attributable to ingestion of arsenic in groundwater and inhalation of hydrogen sulfide gas from passive landfill vents. Because arsenic and hydrogen sulfide have different toxic endpoints and target organs, the addition of the individual HIs is not appropriate, as recommended by USEPA (1989a). Neither HI individually exceeds 1. However, as discussed above, the risk estimates for potential exposure to background groundwater concentrations are greater than the estimates for off-site downgradient residential exposures and are primarily attributed to arsenic concentrations. In addition, the model used to estimate concentrations of hydrogen sulfide and other gasses from passive landfill vents is based on several conservative assumptions, therefore, the risk associated with hydrogen sulfide inhalation may be overestimated. Thus, the results of this BRA indicate that there is negligible incremental risk that may be associated with potential off-site residential exposure to inorganic constituents in groundwater and passive landfill vent gasses. The background risks are higher than the off-site residential risks.

Under hypothetical future use scenarios, the estimated total cancer risk of 1 x 10^{-3} for an on-site resident exceeds the 10^{-4} to 10^{-6} excess cancer risk range considered acceptable by USEPA. The potential total HI of 50 estimated for an on-site resident in the future is also in exceedance of the Agency criterion of 1 (Table 36). The estimated total cancer risk for potential future on-site residential exposure is primarily attributable to vinyl chloride concentrations in groundwater at the Site. The estimated total noncancer risk is mainly attributable to elevated manganese levels in groundwater. However, because manganese is considered an essential nutrient, there is uncertainty associated with the actual risk posed by manganese.

As previously noted in this assessment, the estimated excess cancer risk and HI associated with hypothetical exposure to background groundwater are primarily attributable to arsenic, beryllium, and manganese concentrations. Based on these discussions, the following conclusions can be made concerning metals in groundwater medium at the Berks Landfill:

- The excess cancer risk and HI estimates for potential background (upgradient), and on-site (downgradient) groundwater exposures are mainly attributable to the presence of arsenic and manganese in these areas;
- The estimated cancer risk and HI associated with hypothetical background (upgradient) groundwater exposure are several fold greater than risk estimates associated with potential off-site residential (downgradient) exposures; and,
- The naturally occurring geologic material and acidic nature of the background (upgradient) and on-site/off-site (downgradient) groundwater appears to be responsible for the elevated concentrations of these metals (i.e., arsenic, beryllium, and manganese) in groundwater. Consequently, potential risks posed by the ingestion of these chemicals may be attributed to naturally occurring groundwater conditions in the vicinity of the Berks Landfill, and therefore, not site related.

In the case of potential exposure by off-site residents to modeled volatile compounds in air, under current and future use scenarios, the potential excess cancer risk of 2 x 10^{-5} is within the range of 10^{-4} to 10^{-6} cancer risks levels deemed acceptable by USEPA. The air transport models used in the BRA are based on very conservative exposure parameters that tend to overestimate chemical concentrations at the point of exposure. In addition, it should also be noted that none of the detected chemicals in actual ambient air monitoring samples from leachate lagoons, leachate seep water, or at the Site perimeter exceed USEPA Region III risk-based screening concentrations.

The assessment of both cancer and noncancer risks for potential on-site trespasser exposure to both air and surface soil constituents, under both current and future scenarios, indicate that the estimated risk values are either within, or below, USEPA-recommended target levels of 10^{-4} to 10^{-6} for carcinogens and a HI of 1 for noncarcinogens. Similarly, the estimated total cancer risk and HI for potential future on-site worker exposure to both air and surface soil constituents are also below USEPA-recommended levels.

In summary, based on the results of this assessment, no current or future potential populations are at risk of developing unacceptable potential health risks as a result of hypothetical exposures to COPCs in sediment, surface water, surface soil, or air at the Site. The risk estimates for potential exposure to background groundwater are several fold greater than off-site residential exposures. Exposures to both background and off-site residential groundwater exceed the USEPA acceptable upperbound range under current and future exposure scenarios. Elevated concentrations of arsenic, beryllium, and/or manganese are responsible for the estimated risks associated with these potential exposures. Because arsenic, beryllium, and manganese are present in similar concentrations in background wells upgradient of the Site as compared to off-site and on-site wells that are downgradient, potential risks posed by the ingestion of these metals should be attributed to naturally occurring groundwater conditions in the vicinity of the Berks Landfill.

In the case of potential future on-site residents, the estimated health risks also exceed the USEPA recommended target levels. The cancer risk estimate is mainly attributable to vinyl chloride, while manganese contributes most of the noncancer risk estimate. It is important to emphasize, however, that the likelihood of future residential use at this Site is extremely remote.

12.0 ECOLOGICAL RISK ASSESSMENT

12.1 Objectives and Procedures

The USEPA guidance documents used in the baseline ecological risk assessment (ERA) for Berks Landfill include "Risk Assessment Guidance for Superfund, Vol. II" (USEPA, 1989b); "Framework for Ecological Risk Assessment" (USEPA, 1992c); and "USEPA Region III Environmental Risk Assessment Guidelines" (USEPA 1993b). This ERA is also conducted in accordance with the Baseline Risk Assessment Work Plan (Golder Associates, 1993) and evaluates potential current risks from chemical stressors on ecological receptors that were identified during the Remedial Investigation (Golder Associates, 1995).

The goal of this ERA is to identify potential risks that chemical constituents found in abiotic media may pose to the organisms which potentially reside in and around the Site. These organisms include plants and animals, except humans and domestic animals, that may be exposed to Site-related chemicals in soil, sediment, surface water, and leachate.

All chemical constituents detected during three phases of remedial investigation sampling are considered in this ERA. A model of potential exposure pathways in environmental media and related potential ecological effects on a potential primary receptor is developed and evaluated in this section of the report. Based on evaluation of the model, potential risk is characterized and described in this ecological assessment. To assess the reliability of analytical data and exposure/receptor models, associated uncertainties are qualitatively analyzed as well.

12.2 Identification of Potential Stressors

This baseline ERA considers chemical stressors as a general analysis of potential risk for inhabitants of the Site and visiting wildlife whose home ranges include the Site. It should be noted that all detected chemicals in samples collected during the RI from surface soil, sediment, surface water, and leachate media at the landfill are considered in this assessment. Neither background nor risk-based screening of analytical results is conducted to select COPCs for the ERA. Therefore, all detected chemical analytes (summarized in Tables 5 through 11) are used in the assessment.

The calculated "reasonable maximum exposure" (RME) concentrations are used to evaluate potential risk to environmental receptors, as discussed in Section 12.6.1, in accordance with USEPA (1993b) guidelines for ecological risk assessment. The RME concentration represent the lower of either the 95% upper confidence limit of the arithmetic mean or the maximum detected concentration in the environmental media.

12.3 Ecosystem Components

Terrestrial, wetland and aquatic habitats found at the Site have been assessed in the RI report (Golder Associates, 1995) and are summarized below. The reader is referred to the RI report for a more complete discussion of environmental habitats, if necessary.

The Site is surrounded largely by deciduous forest, as well as cropland and open space. The western landfill is primarily covered with shrubs, saplings, and grasses, and has side slopes covered by deciduous woodlands. The eastern landfill is covered mainly with grasses and some shrubs and is surrounded by a perimeter fence. The largest water body at the Site is a tributary of Cacoosing Creek which flows from east to west across the north central portion of the Site. Two small second order streams, which originate south of the Site, flow north through the Site before joining the Cacoosing Creek tributary. The Cacoosing Creek tributary flows off-site in a northwesterly direction for about 1 mile off-site before joining Cacoosing Creek. Cacoosing Creek flows north and joins the Tulpehocken Creek, which then flows in a northerly direction before joining the Schuylkill River in the city of Reading, approximately 7 miles north of the Site.

Floodplain and riparian zone wetlands flank the tributary of Cacoosing Creek in the northern portion of the Site, as well as sections of the drainage paths and secondary tributaries that traverse the Site. Approximately 16 acres of floodplain and riparian zone wetlands have been identified at the Site (see Figure 3-30 of the RI report). Also, pockets of seepage wetland are scattered across the Site in conjunction with seeps and small depressions. The seepage wetlands did not exist prior to landfill construction. Appendix L of the RI report provides the field methods and data collected to delineate the wetland boundaries at the Site.

During the terrestrial habitat assessment (see Appendix M of the RI report), eastern cottontail and white-tailed deer were observed most frequently on the western landfill. The meadow vole, eastern bluebird, barn swallow, field sparrow, and vesper sparrow were the most prevalent wildlife species observed on the eastern landfill. A perimeter fence restricts access to the eastern landfill; consequently, wildlife exposure to chemicals in the soil is generally limited to only small mammals and avian species. No exposure to chemicals in the soil is generally limited to only small mammals and avian species. No wildlife or plant species observed at the Site are included on federal or Pennsylvania Endangered Species lists as of the date of this assessment.

The terrestrial habitat assessment identified numerous ecologically similar habitats at and around the landfill. No apparent differences between similar on-site and off-site habitats were observed during biological assessments. In addition, no unique habitat features exist at the Site. Ecological habitats identified at the Site are briefly described below.

Rangeland - Herbaceous

The majority of the area encompassed by the eastern landfill, the southern portion of the top of the western landfill, and the majority of the former borrow area to the west of the western landfill (see Figure 1) are early to mid succession old field. Areas on the landfill surface generally show only minor impacts resulting from landfilling practices. Also, several localized areas of bare ground surface result from poor soil or steep slopes; otherwise, vegetation is healthy and abundant. The primary plant cover species are yellow and white sweet clover, crown vetch, and grasses utilized to stabilize the soil cover. Meadow voles and sparrows were most frequently observed during the terrestrial habitat assessment.

Rangeland - Shrub/Brush

The majority of the western landfill is shrub/brush habitat. In addition, areas under the high tension electric towers and cables to the east of the Site and areas further to the east of the electric utility right-of-way are shrub/brush habitat. This habitat type provides good cover for wildlife. Eastern cottontail and white-tailed deer were the most frequently observed wildlife species in this habitat.

Forest Land - Deciduous

The majority of forested areas at the landfill are mesophytic second stand, mature forest. Black locust, white ash, red maple, and honeylocust were commonly observed. Most forested areas at the Site have a dense understory of shrubs and saplings. Also, on the eastern landfill, multiflora rose and climbing bittersweet were commonly observed. These species also were commonly seen on the western landfill, as were the bush honeysuckle and Japanese honeysuckle.

Wildlife diversity is typically higher in this habitat type than most others as a result of the greater variety of forage habitats and feeding guilds. Species that utilize both hard and soft mast (e.g., gray squirrel) or cavity dwellers (e.g., squirrels, raccoons, owls, bats, or woodpeckers) could occur in this habitat type. Raccoon, striped skunk, and gray squirrel were among the mammals observed at the Site. Also, birds seen at the Site include those species utilizing both hard and soft mass, such as the hairy woodpecker and downy woodpecker.

Wetlands and Streams

Both wetlands and streams are located within stream corridors and floodplain areas of the Site. Because the first order streams are upper headwater tributaries, only a few non-game fish species are expected in such a habitat. During the terrestrial habitat assessment, minnows were observed at five of the six sample locations. Raccoons were also observed in this habitat.

Inhabitants of streambeds were qualitatively evaluated during the aquatic habitat assessment (see Appendix N of the RI report). Diverse communities of benthic macroinvertebrate species were found throughout the six sample locations, two of which were background sample points. In most cases, more than 100 organisms were collected at each of eight kick sample collection points per sample location. Notably, pollution intolerant species predominated, including those species that USEPA has identified as pollution intolerant species, commonly referred to as "EPT" -- Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). Furthermore, relatively low levels of pollution tolerant orders, such as Diptera and Annelida, were observed at the Site. These results indicate that the stream systems both upstream and at the Site are suitable, healthy aquatic habitats.

12.4 Endpoint Selection

This ERA combines analytical data from soil, sediment, surface water, and leachate samples with modeled data and other supportive information to evaluate potential exposure of ecological receptor species to organic and inorganic constituents. For soils, the measurement endpoint is the predicted dose to individual receptors as discussed in Section 12.6. The measurement endpoint for sediments, surface water, and leachate is the exposure point concentration (i.e., the measured constituent concentrations in the media). The desired assessment endpoint for all biota is the health of selected receptor organisms and their local populations.

Because evaluation of all potential effects on all potential receptors is impossible, the exposure point concentrations for selected receptors are compared to appropriate benchmarks. For this ERA, the meadow vole was selected in the approved Baseline Risk Assessment Work Plan (Golder Associates, 1993) as a potential primary receptor for evaluating risks from chemicals in the soil. The meadow vole's potential exposure to Site-related chemicals in the soil is evaluated in this ERA by using a pathway model. The receptors for sediments, surface water, and leachate at the Site are generic aquatic species, as represented by published federal and state water and sediment quality criteria documents. At the request of USEPA Region III, detected concentrations of chemicals in leachate are compared to water quality criteria in this ERA, although landfill leachate is not considered an important habitat and is not expected to support a limited aquatic life.

12.5 Conceptual Model

A conceptual ecological model is developed based on the identified ecological resources present at the Site and under the assumption that a chemical is limited to the sampled media. Key receptors evaluated in this ecological assessment are the meadow vole for the soil medium, and generic aquatic species for the sediment, surface water, and leachate media.

The potential chemical exposure pathway evaluated for the meadow vole is through the food chain. Available data from (USEPA, 1993c) indicate that the diet of the meadow vole is comprised mainly (95 to 100%) of vegetative matter, such as shoots, seeds, roots, and fungi. The remainder of the diet is comprised of insects. Because plants represent the predominant pathway for potential exposure to chemicals in soil, earthworms are, therefore, not considered in this ERA.

In this model, uptake of chemicals from soil by vegetation serves as the basic mechanism of chemical entry into the food chain for the terrestrial ecosystem. Soil/plant uptake factors are presented in Table 38. The herbivore component, represented in the conceptual model by the meadow vole, acts as the primary conduit between constituents in vegetation and constituent transfer to higher trophic levels. The size of the landfill is much larger than the home range of the vole. Therefore, it is assumed that the vole spends its entire life on the landfill and ingests only vegetation that grows on the Site.

The potential chemical exposure pathway evaluated for generic aquatic species is through direct exposure to the potentially contaminated media. For potential effects to aquatic ecosystems, the conceptual model considers only direct exposure to chemicals detected in samples of the media. In accordance with the approved Baseline Risk Assessment Work Plan (Golder Associates, 1993), the conceptual model does not consider chemical uptake or transport among trophic levels.

12.6 Exposure Analysis

The exposure analysis phase of the ERA is a technical evaluation of the available analytical data to assess the potential effects of exposure to the stressors on previously identified receptors. This analysis uses the conceptual model as a basis to characterize potential exposure and ecological effects. This exposure analysis is considered to be a screening level approach, as described in USEPA (1993b), because site-specific data for potential environmental receptors (plants and animals) are not available.

12.6.1 Exposure Characterization

The uptake of chemicals from soil by plants represents the principal route of chemical exposure for the meadow vole. It is assumed that the meadow vole spends all of its life on the landfill; that it obtains all of its food from the Site; and that its entire food source is vegetation and is impacted by constituents. In addition to consumption of plants, incidental ingestion of contaminated soil as a fraction of the meadow vole's diet is considered in the model.

For exposure characterization, the reasonable maximum exposure (RME) concentrations for detected chemicals are used as the basis for calculating chemical uptake by terrestrial plants, soil intake for the meadow vole, and chemical exposure for aquatic species. These RME concentrations are shown in Tables 39 through 42. The RME concentrations were calculated using the same approach described in the human health risk assessment (Section 6.0). It is assumed that these concentrations are uniformly distributed in the sampled media, are biologically active, and are available for transport into the biosphere.

12.6.2 Chemical Intake by Terrestrial Receptors

The intake of chemicals by the vole is estimated from soil concentrations, appropriate transfer coefficients, and species-specific intake factors. Soil-to-plant uptake factors for constituents found in soil, if available, are shown in Table 38. These uptake factors are from available literature (Baes et al., 1984; Travis and Arms, 1988). The factors do not account for chemical bioavailability, biodegradation, or metabolic transformation of compounds and are therefore conservative. Chemical concentration (or activity) in plants is calculated by

$$C_{iv} = (C_{is})(Sp)(Dw) \qquad (1)$$

where:

$C_{i,v}$	=	concentration of chemical i in vegetation (mg/kg plant, wet weight);
$C_{i,s}$	=	concentration (RME, Table 39) of chemical i in soil (mg/kg soil, dry weight);
Sp	=	soil-to-plant uptake factors (Table 38, kg soil/kg plant, dry weight); and,
Dw	=	dry-to-wet weight conversion (0.32).

The uptake factors used in this assessment are for soil to vegetative parts, with no distinction made for seeds or other plant parts.

The estimated chemical intake or dose (CD) by the meadow vole is calculated using basic intake equations adapted from USEPA (1989a):

$$CD = I_{i,o} = \frac{(C_{i,v})(IR)(FI)(EF)(ED)}{(BW)(AT)} \qquad (2)$$

where:

$I_{i,o}$	=	intake rate of chemical by organism (mg/kg/day);
$C_{i,v}$	=	concentration of chemical i in vegetation (from Equation 1, mg/kg, wet weight);
IR	=	ingestion rate (kg/day);
FI	=	fraction of food ingested from potentially contaminated area;
EF	=	exposure frequency (days/year);
ED	=	exposure duration (years);
BW	=	body weight (kg); and,
AT	=	averaging time (days).

The potential ingestion rate for the receptor is estimated based on average body weight of 44 g (Reich, 1981) and the allometric equation $IR(kg/d)=0.621W^{0.564}$ where W is body weight in kg (Suter, 1993). For this ecological assessment, exposure frequency is assumed to equal 365 days per year; exposure duration is assumed to equal 1 year; and averaging time is assumed to equal 365 days. The fraction of food ingested from a potentially contaminated area (FI) is an estimate based on the home range or species density of the organism and is assumed to be equal to 1.0 (i.e., 100%) for meadow voles at the landfill.

Equation (2) is used to estimate the potential intake rate of chemical constituents from vegetation by the vole (CD_v). The same equation and variables are used to estimate the intake of chemicals from soil (CD_s) by the vole except for the use of a soil ingestion rate for the meadow vole (i.e., 2.4% of diet, according to Beyer et al., 1994).

12.6.3 Exposure Profile

The calculated chemical intakes, or doses (CD_v, CD_s and CD Total), to the meadow vole for chemicals in soil are shown in Table 39. The calculated intakes are not necessarily representative of actual chemical intakes by an individual receptor at the Site. These estimates of chemical intakes/doses are used together with toxicity information to evaluate potential risk at a site under the assumption of no remedial action. No Site-specific toxicity data are available to evaluate the estimated doses or exposures to the selected environmental receptors.

12.6.4 Ecological Toxicity Assessment

This ERA focuses on potential adverse effects to wildlife receptors as a consequence of exposure to chemicals that have been detected at the Site. Ecological effects are characterized by identifying critical intake or exposure values that may result in adverse effects to wildlife receptors.

For chemicals found in soil, the toxicity measurement endpoint used for evaluation is the median lethal dose (LD_{50}). The LD_{50}s used in this ecological assessment are based on animal study (rat or mouse) data listed in the Registry of Toxic Effects of Chemical Substances (RTECS) data base (NIOSH, 1994). Studies based on intraperitoneal administered doses are used only when studies using oral administered doses are unavailable. The results of the rat and mouse studies are scaled to the meadow vole to account for differences in body surface area by using the methodology presented in Opresko et al. (1993). In addition, No Observed Adverse Effects Levels (NOAELs) for the meadow vole are derived from animal studies (rat or mouse) listed in the Integrated Risk Information System (IRIS) data base (USEPA, 1994b) to evaluate toxicity of chemicals found in soil. Uncertainty factors are applied to the rat or mouse toxicity data to modify lowest observed effects levels to NOAELs or to adjust subchronic values to chronic values. The rat or mouse NOAELs are scaled to the meadow vole to account for differences in body surface area. The toxicity results for species used to evaluate the soil medium are presented in Table 38.

For chemicals found in sediment, the toxicity measurement endpoints are the effects range-low (ER-L) and effects range-median (ER-M) data from Long and Morgan (1991). An ER-L value defines the concentration at the low-end of the range in which effects were observed. An ER-M concentration defines a point midway in the range of reported values associated with biological effects.

For chemicals found in surface water, leachate lagoon, and leachate seeps, chronic toxicity benchmarks are the lower of ambient water quality criteria (AWQC) for aquatic life established by USEPA in "Quality Criteria for Water Update #2 1987," (USEPA, 1987) and 40 CFR Part 131, Volume 57, No. 60848-60923 (USEPA, 1992), or Pennsylvania Water Quality Standards for aquatic life established by PADER in Pennsylvania Code, Title 25, Chapter 16.

For chemicals with no reported ER-L, ER-M, or AWQC, both RTECs and the Hazardous Substance Data Bank (HSDB, 1994) were examined for equivalent toxicity information for representative aquatic species (e.g., Notropis, spp.). For several constituents, no toxicity information was available after an exhaustive search of appropriate data bases. As a result, these constituents are not evaluated as noted in the results.

12.7 Risk Characterization

Potential risks to ecological receptors are characterized in this ERA by using the quotient method (Suter, 1993). In this method, the environmental concentration or receptor dose is divided by an appropriate toxicological endpoint. An environmental hazard quotient (EHQ) less than one (1) or unity indicates a negligible probability of adverse effects. If the EHQ is greater than one, then there may be a possible ecological effect. As the magnitude of the quotient increases, the likelihood of possible effects is assumed to increase. EHQs of the same order of magnitude are assumed to indicate equivalent risk as a result of the evaluation methods. The environmental hazard index (EHI), which is the sum of EHQs for all chemicals, is used to assess the potential adverse effect to a receptor from exposure to multiple chemicals. The EHI assumes that the toxicity of chemicals to the receptors is additive, and does not consider synergistic, antagonistic, or potentiating effects of chemicals. This risk characterization is suitable for identifying possible organism-level effects. Effects to higher ecological organizations may be extrapolated from these results.

12.7.1 Risk to Receptors

Potential Risks from Exposure to Soil

No chemicals found in soil samples collected at the landfill have an EHQ greater than one (Table 39) using the LD_{50} as the toxicity benchmark. If the NOAEL is used as the benchmark, both aluminum and copper have an EHQ greater than one (Table 39). However, concentrations of aluminum and copper found in background soil samples result in EHQs of similar magnitude to those found at the landfill. The highest detected concentration of copper was detected in a background surface soil sample. The soil that was used to cover the landfill was taken from surrounding land and is likely to contain similar quantities of chemicals found in the background samples. In addition, mining activities were historically conducted in the vicinity of the Site indicating high mineralization of the natural geologic materials in the area. Based on these factors, it is unlikely that the analytes detected in the soil at the landfill represent any additional risk to the meadow vole.

Potential Risks from Exposure to Sediment

None of the chemicals detected in on-site stream sediments exceed an EHQ of one when evaluated using the most conservative ER-L as the toxicity benchmark (Table 40). The EHI exceeds one when either the ER-L or the ER-M is used as the toxicity benchmark. Once again, the EHI for background sediment is very similar in magnitude to the EHI for on-site sediment. The sediment samples collected on-site exhibited a smaller grain size and higher total organic carbon content than the off-site samples, which would tend to magnify constituent concentrations in the on-site samples. This comparison suggests that the Site poses negligible potential environmental effects with respect to exposure to sediment.

Potential Risks from Exposure to Surface Water

As described in the RI report (Golder Associates, 1995), cyanide was only detected in one of three on-site surface water samples during the Phase 1A sampling event. However, it was not detected in the other two Phase 1A surface water samples, nor was it detected in any of the eight Phase 1B surface water samples, including five samples taken specifically to verify the presence of cyanide in surface water. Cyanide has not been detected in any soil, sediment, leachate seep, or leachate lagoon samples. Thus, cyanide may no longer be present at detectable levels at the Site and its detection during Phase 1A is considered to represent an anomaly of actual Site conditions. Therefore, cyanide is not considered a chemical of interest for surface water at the Site.

None of the chemicals in surface water has an EHQ greater than one, with the exception of cyanide (Table 41). The EHI for on-site surface water is greater than one, but when cyanide is excluded, the EHI for on-site surface water is actually equivalent to the EHI for background surface water.

The aquatic habitat assessment results (see Appendix N of RI report) provide additional information in evaluating the health of the aquatic habitat and potential risks to receptors in surface water. As stated in the aquatic habitat assessment, all of the six benthic sample points (two background and four on-site) have a similar benthic macroinvertebrate community structure and diversity. This structure shows an abundance of pollutant intolerant species. The similarity between background and on-site aquatic habitats shows that stream systems at and around the Site support normal, abundant, benthic communities rich in taxa diversity. In addition, no Site-related impact on these habitats or their community structure were observed during the assessment.

Therefore, based on the comparison of detected chemical concentrations in surface water with water quality criteria, it can be stated that the Site poses no potential environmental risks to receptors with respect to exposure to surface water.

Potential Risks from Exposure to Leachate

Chemicals are present either in the leachate lagoon or in leachate seeps at concentrations that may pose a potential risk to aquatic organisms. Most notably, iron concentrations both in the lagoon and the seeps exceed water quality criteria (Table 42). Other analytes detected in leachate that exceed water quality criteria include phenol, toluene, and total xylenes in the leachate lagoon, and cobalt in the leachate seeps. Although these chemicals represent a possible effect on aquatic receptors leachate is not an important aquatic habitat and is only expected to support limited aquatic life at the Site.

12.7.2 Uncertainty Analysis

This ecological risk assessment is based only on estimates of potential exposure to chemical concentrations that are assumed to be uniformly distributed within abiotic media at the landfill. No empirical data are available that can be used to validate the exposure estimates or toxicity effects presented in this ecological risk assessment. Modeling from soil to potential ecological receptors requires a number of assumptions, including soil-to-plant transfer factors. No evaluation or critical review has been conducted to determine if these transfer coefficients are relevant to conditions at the landfill. The lack of Site-specific toxicity information for all analytes, species-specific toxicity information, and the assumptions and uncertainties incorporated into the estimates of NOAELs are additional sources of uncertainty. Based on the assumptions and identified limitations, the potential risks are considered to be order-of-magnitude estimates. Estimates of the same order of magnitude are considered equivalent. As a result, the EHIs for on-site soil, sediment, and surface water exposures are considered equivalent to the background EHIs for the same media.

12.8 Conclusions

In summary, chemical constituents in Site environmental media pose no additional risk to environmental receptors in soil, sediment, or surface water. Although comparison of detected chemicals in leachate with water quality criteria produces values indicative of potential risk, leachate is not considered an important aquatic habitat and is only expected to support a limited aquatic life. Therefore, it can be concluded in this ERA that chemicals of interest in environmental media at the Site do not pose unacceptable risks to primary ecological receptors.

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TABLE 1
SUMMARY OF DETECTED CHEMICALS IN BACKGROUND GROUNDWATER SAMPLES[1]
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[2]	Frequency Of Detection[3]	Range Of Detected Concentrations (mg/l)[4]	Arithmetic Mean (mg/l)[5]
1,2-Dichloroethane	1/19	ND - 0.0005	0.00216
Bromomethane	1/19	ND - 0.014	0.003
Chloromethane	1/19	ND - 0.02	0.003
Aluminum	7/8	ND - 58.3	25.783
Arsenic	5/10	ND - 0.008	0.006
Barium	7/9	ND - 0.173	0.091
Beryllium	3/10	ND - 0.006	0.003
Cadmium	2/10	ND - 0.013	0.004
Calcium	10/10	20.2 - 62.7	37.65
Chromium	4/10	ND - 0.098	0.025
Cobalt	6/10	ND - 0.028	0.024
Copper	8/9	ND - 0.272	0.094
Cyanide	1/3	ND - 0.045	0.018
Iron	7/8	ND - 66.4	32.114
Lead	7/9	ND - 0.017	0.007
Magnesium	10/10	4.29 - 22.6	12.599
Manganese	7/10	ND - 1.24	0.499
Nickel	2/9	ND - 0.076	0.025
Potassium	8/10	ND - 4.09	1.99
Sodium	10/10	5.41 - 12.3	7.914
Vanadium	9/10	ND - 0.156	0.07
Zinc	7/8	ND - 0.136	0.073

Notes:

The determination of frequency of detections and the calculation of mean concentrations are performed in accordance with the procedures outlined in Risk Assessment Guidance For Superfund (RAGS), Volume 1 (USEPA, 1989a) and Guidance for Data Usability in Risk Assessment, Interim Final (USEPA, 1990).

[1] Based on chemical concentrations in Monitoring Wells G-2, G-3, G-7, G-8, and G-10; Residential Wells CASS, REIFSNYDER, and HEINZ.

[2] Constituent is listed if it was detected at a frequency of at least once in the environmental media. Only constituents qualified with an A, J, K, or L are considered detected.

[3] Frequency of Detection is the number of times a constituent is detected over the number of times a constituent was analyzed in each media. Data qualified with an N, B, JN or R are not counted in the determination of frequency of detection.

[4] ND = Not detected.

[5] Mean is the Arithmetic Mean where:

- Field duplicate and primary sample results are averaged for a given sample value
- The highest value of either the primary or reanalysis is used for a given sample
- One-half the SQL or CRDL is used as the result for data containing 'U' in its qualifier
- One-half the reported value is used for data qualified as K or L
- The full reported value is used for data qualified as A or J

TABLE 2
SUMMARY OF DETECTED CHEMICALS IN ONSITE GROUNDWATER SAMPLES
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[1]	Frequency Of Detection[2]	Range Of Detected Concentrations[3] (mg/l)	Arithmetic Mean[4] (mg/l)
1,1,1-Trichloroethane	1/43	ND - 0.006	0.010
1,1,2-Trichloroethane	1/43	ND - 0.001	0.009
1,1-Dichloroethane	17/43	ND - 0.009	0.010
1,1-Dichloroethene	2/43	ND - 0.014	0.010
1,2-Dichloroethane	3/43	ND - 0.002	0.010
1,2-Dichloropropane	2/43	ND - 0.002	0.010
2-Butanone	2/38	ND - 0.039	0.012
Acetone	3/37	ND - 0.019	0.011
Benzene	10/43	ND - 0.013	0.010
Carbon Disulfide	1/43	ND - 0.003	0.010
Chlorobenzene	14/43	ND - 0.022	0.011
Chloroethane	6/42	ND - 0.027	0.010
Chloromethane	1/43	ND - 0.006	0.010
Ethylbenzene	2/43	ND - 0.023	0.011
Tetrachloroethene	1/43	ND - 0.001	0.009
Total 1,2-Dichloroethene	14/38	ND - 3.7	0.208
Total Xylenes	2/43	ND - 0.11	0.015
Trichloroethene	11/43	ND - 3.1	0.140
Vinyl Chloride	11/43	ND - 0.37	0.021
cis-1,2-Dichloroethene	6/7	ND - 0.007	0.002
1,2-Dichlorobenzene	2/41	ND - 0.002	0.004
1,3-Dichlorobenzene	1/41	ND - 0.009	0.005
1,4-Dichlorobenzene	13/39	ND - 0.010	0.005
2,4-Dimethylphenol	1/38	ND - 0.004	0.005
3-Nitroaniline	1/37	ND - 0.001	0.012
4-Methylphenol	1/38	ND - 0.001	0.005
4-Nitroaniline	1/37	ND - 0.007	0.012
Butylbenzylphthalate	3/37	ND - 0.002	0.005
Di-n-Octyl Phthalate	1/37	ND - 0.004	0.005
Di-n-butylphthalate	1/24	ND - 0.001	0.005
Diethylphthalate	1/24	ND - 0.022	0.006
Hexachloroethane	2/37	ND - 0.006	0.005
Isophorone	2/37	ND - 0.002	0.005
N-Nitroso-di-n-propylamine	1/37	ND - 0.001	0.005
Naphthalene	4/39	ND - 0.005	0.005
bis(2-Ethylhexyl)Phthalate	4/12	ND - 0.095	0.005

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TABLE 2
SUMMARY OF DETECTED CHEMICALS IN ONSITE GROUNDWATER SAMPLES
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[1]	Frequency Of Detection[2]	Range Of Detected Concentrations[3] (mg/l)	Arithmetic Mean[4] (mg/l)
Aluminum	17/17	0.618 - 147	20.121
Arsenic	19/38	ND - 0.028	0.007
Barium	36/37	ND - 1.37	0.220
Beryllium	7/38	ND - 0.006	0.002
Cadmium	6/29	ND - 0.014	0.003
Calcium	39/39	13.4 - 476.5	164.699
Chromium	10/39	ND - 0.085	0.012
Cobalt	15/39	ND - 0.034	0.022
Copper	27/34	ND - 0.248	0.033
Iron	34/34	0.126 - 119	14.837
Lead	18/35	ND - 0.233	0.013
Magnesium	39/39	4.97 - 153	49.941
Manganese	38/38	0.016 - 27.6	3.302
Mercury	1/35	ND - 0.00025	0.0001
Nickel	13/37	ND - 0.104	0.025
Potassium	33/39	ND - 32.6	6.207
Selenium	1/11	ND - 0.004	0.003
Silver	1/35	ND - 0.003	0.005
Sodium	39/39	3.45 - 429	47.591
Vanadium	14/39	ND - 0.111	0.026
Zinc	23/23	0.016 - 0.919	0.133

Notes:

The determination of frequency of detections and the calculation of mean concentrations are performed in accordance with the procedures outlined in Risk Assessment Guidance For Superfund (RAGS), Volume 1 (USEPA, 1989a) and Guidance for Data Usability In Risk Assessment, Interim Final (USEPA, 1990).

[1]Based on chemical concentrations in Monitoring Wells C-1, C-2, C-3, C-4, C-5, C-6, C-7, G-1, G-5, G-6, G-11, G-12, G-13, GR-18, GR-19, MD-2, MP-3, MP-6, MP-11, M-15, M-16, M-17, MP-18, and MP-19; Residential Wells NEIN, and Auction House.

[2]Constituent is listed if it was detected at a frequency of at least once in the environmental media. Only constituents qualified with an A, J, K, or L are considered detected.

[3]Frequency of Detection is the number of times a constituent is detected over the number of times a constituent was analyzed in each media. Data qualified with an N, B, JN or R are not counted in the determination of frequency of detection.

[4]ND = Not detected.

[5]Mean is the Arithmetic Mean where:
- Field duplicate and primary sample results are averaged for a given sample value
- The highest value of either the primary or reanalysis is used for a given sample
- One-half the SQL or CRDL is used as the result for data containing 'U' in its qualifier
- One-half the reported value is used for data qualified as K or L
- The full reported value is used for data qualified as A or J

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TABLE 3
SUMMARY OF DETECTED CHEMICALS IN OFFSITE RESIDENTIAL GROUNDWATER SAMPLES[1]
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[2]	Frequency Of Detection[3]	Range Of Detected Concentrations[4] (mg/l)	Arithmetic Mean[5] (mg/l)
1,1,2-Trichloroethane	1/32	ND - 0.0006	0.001
1,2-Dichloroethane	2/32	ND - 0.002	0.001
Chloroform	1/32	ND - 0.0006	0.001
Toluene	1/32	ND - 0.0009	0.001
Arsenic	1/3	ND - 0.006	0.005
Barium	2/2	0.0233 - 0.028	0.026
Calcium	3/3	51.7 - 70.7	64.2
Copper	1/2	ND - 0.0311	0.0218
Magnesium	3/3	0.857 - 2.47	1.92
Nickel	1/3	ND - 0.0418	0.027
Potassium	1/3	ND - 0.466	1.82
Sodium	3/3	27.9 - 37.9	28.9
Zinc	1/1	0.01 - 0.01	0.01

Notes:
The determination of frequency of detections and the calculation of mean concentrations are performed in accordance with the procedures outlined in Risk Assessment Guidance For Superfund (RAGS), Volume 1 (USEPA, 1989a) and Guidance for Data Usability in Risk Assessment, Interim Final (USEPA, 1990).

[1] Based on chemical concentrations in Monitoring Wels Bechtald, Berkel, Botch/Roberts, Breitegam, Buller, Cremer, and Faust.

[2] Constituent is listed if it was detected at a frequency of at least once in the environmental media. Only constituents qualified with an A, J, K, or L are considered detected.

[3] *Frequency of Detection is the number of times a constituent is detected over the number of times a constituent was analyzed in each media.* Data qualified with an N, B, JN or R are not counted in the determination of frequency of detection.

[4] ND = Not detected.

[5] Mean is the Arithmetic Mean where:
- Field duplicate and primary sample results are averaged for a given sample value
- The highest value of either the primary or reanalysis is used for a given sample
- One-half the SQL or CRDL is used as the result for data containing 'U' in its qualifier
- One-half the reported value is used for data qualified as K or L
- The full reported value is used for data qualified as A or J

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TABLE 4
SUMMARY OF DETECTED CHEMICALS IN BACKGROUND SURFACE SOIL SAMPLES[1]
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[2]	Frequency Of Detection[3]	Range Of Detected Concentrations[4] (mg/kg)	Arithmetic Mean[5] (mg/kg)
Butylbenzylphthalate	1/3	ND - 0.044	0.15
Chrysene	1/3	ND - 0.047	0.15
Fluoranthene	1/3	ND - 0.068	0.15
Pyrene	1/3	ND - 0.041	145
Aluminum	3/3	19,200 - 26,600	23,933
Arsenic	3/3	4.2 - 4.5	2.18
Barium	3/3	95.4 - 151	120
Beryllium	2/3	ND - 1.5	1.2
Calcium	3/3	2,720 - 5,740	4,030
Chromium	2/3	ND - 91.8	48.1
Cobalt	3/3	16.1 - 34.8	21.8
Copper	3/3	31.8 - 408	167
Iron	3/3	26,100 - 65,900	45,200
Lead	3/3	31.2 - 37.4	22
Magnesium	3/3	2,200 - 3,550	3,083
Manganese	3/3	712 - 1,350	537
Nickel	3/3	11.2 - 37.3	23.6
Potassium	3/3	619 - 3,130	1,552
Vanadium	3/3	67.6 - 152	96.9
Zinc	3/3	95.9 - 151	116

Notes:

The determination of frequency of detections and the calculation of mean concentrations are performed in accordance with the procedures outlined in Risk Assessment Guidance For Superfund (RAGS), Volume 1 (USEPA, 1989a) and Guidance for Data Usability In Risk Assessment, Interim Final (USEPA, 1990).

[1]Based on chemical concentrations in surface soil samples S1-BG, S2-BG, and S3-BG.

[2]Constituent is listed if it was detected at a frequency of at least once in the environmental media. Only constituents qualified with an A, J, K, or L are considered detected.

[3]Frequency of Detection is the number of times a constituent is detected over the number of times a constituent was analyzed in each media subgroup. Data qualified with an N, B, JN or R are not counted in the determination of frequency of detection.

[4]ND = Not detected.

[5]Mean is the Arithmetic Mean where:
- Field duplicate and primary sample results are averaged for a given sample value
- The highest value of either the primary or reanalysis is used for a given sample
- One-half the SQL or CRDL is used as the result for data containing 'U' in its qualifier
- One-half the reported value is used for data qualified as K or L
- The full reported value is used for data qualified as A or J

TABLE 5
SUMMARY OF DETECTED CHEMICALS IN ONSITE SURFACE SOIL SAMPLES[1]
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[2]	Frequency Of Detection[3]	Range Of Detected Concentrations (mg/kg)[4]	Arithmetic Mean (mg/kg)[5]
2-Butanone	4/19	ND - 0.014	0.007
4-Methyl-2-Pentanone	1/19	ND - 0.004	0.006
Acetone	1/3	ND - 0.11	0.041
Chlorobenzene	1/18	ND - 0.002	0.006
Chloroform	1/19	ND - 0.006	0.006
Ethylbenzene	3/19	ND - 0.037	0.008
Toluene	3/19	ND - 0.18	0.015
Total Xylenes	4/18	ND - 0.073	0.01
1,4-Dichlorobenzene	1/19	ND - 0.12	0.2
2-Methylnaphthalene	2/19	ND - 0.12	0.191
Acenaphthene	2/19	ND - 0.38	0.202
Anthracene	2/19	ND - 0.655	0.217
Benzo(a)Anthracene	2/19	ND - 1.85	0.285
Benzo(a)Pyrene	2/19	ND - 1.21	0.249
Benzo(b)Fluoranthene	1/18	ND - 0.15	0.199
Benzo(g,h,i)Perylene	1/19	ND - 0.63	0.224
Benzo(k)Fluoranthene	1/18	ND - 0.068	0.194
Butylbenzylphthalate	2/19	ND - 0.063	0.192
Carbazole	1/19	ND - 0.37	0.21
Chrysene	2/19	ND - 1.5	0.267
Di-n-Octyl Phthalate	1/19	ND - 0.054	0.2
Dibenz(a,h)Anthracene	1/19	ND - 0.32	0.208
Dibenzofuran	2/19	ND - 0.26	0.196
Fluoranthene	7/19	ND - 3.15	0.326
Fluorene	2/19	ND - 0.46	0.206
Indeno(1,2,3-cd)Pyrene	1/19	ND - 0.58	0.221
Naphthalene	2/19	ND - 0.4	0.208
Pentachlorophenol	1/19	ND - 0.11	0.483
Phenanthrene	4/19	ND - 2.9	0.333
Phenol	1/19	ND - 0.12	0.202
Pyrene	5/19	ND - 2.7	0.312
Aroclor-1248	1/6	ND - 0.27	0.04

TABLE 5
SUMMARY DETECTED CHEMICALS IN OF ONSITE SURFACE SOIL SAMPLES[1]
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[2]	Frequency Of Detection[3]	Range Of Detected Concentrations[4] (mg/kg)	Arithmetic Mean[5] (mg/kg)
Aluminum	19/19	5,430 - 33,400	20,731
Antimony	2/14	ND - 4.3	6.47
Arsenic	14/14	1.6 - 30.9	6.32
Barium	19/19	38.9 - 933	125
Beryllium	14/19	ND - 2	1.09
Cadmium	5/18	ND - 9.1	2.2
Calcium	19/19	2,040 - 20,600	6,896
Chromium	19/19	18.1 - 1,180	151
Cobalt	19/19	10.9 - 55.4	19.8
Copper	19/19	10.4 - 247	47.7
Iron	19/19	21,800 - 200,000	43,621
Lead	19/19	5.3 - 176.7	14.4
Magnesium	19/19	2,800 - 37,500	10,964
Manganese	19/19	293 - 6,030	798
Mercury	7/19	ND - 0.26	0.08
Nickel	19/19	21.5 - 771	96
Potassium	11/11	266.5 - 2,140	1,058
Selenium	2/19	ND - 66.2	4.31
Silver	1/19	ND - 0.67	1.15
Sodium	4/4	376 - 2,310	1,350
Vanadium	19/19	25.7 - 137	65.9
Zinc	19/19	57.1 - 332	103

Notes:

The determination of frequency of detections and the calculation of mean concentrations are performed in accordance with the procedures outlined in Risk Assessment Guidance For Superfund (RAGS), Volume 1 (USEPA, 1989a) and Guidance for Data Usability in Risk Assessment, Interim Final (USEPA, 1990).

[1]Based on chemical concentrations in surface soil samples S1-EL, S1-WL, S2-EL, S2-WL, S3-EL, S3-WL, S4-EL, S4-WL, S5-EL, S5-WL, S6-EL, S6-WL, S7-EL, S7-WL, S8-EL, S8-WL, S9-EL, S10-EL, and S11-EL.

[2]Constituent is listed if it was detected at a frequency of at least once in the environmental media. Only constituents qualified with an A, J, K, or L are considered detected.

[3]Frequency of Detection is the number of times a constituent is detected over the number of times a constituent was analyzed in each media. Data qualified with an N, B, JN or R are not counted in the determination of frequency of detection.

[4]ND = Not detected.

[5]Mean is the Arithmetic Mean where:
Field duplicate and primary sample results are averaged for a given sample value
The highest value of either the primary or reanalysis is used for a given sample
One-half the SQL or CRDL is used as the result for data containing 'U' in its qualifier
One-half the reported value is used for data qualified as K or L
The full reported value is used for data qualified as A or J

TABLE 6
SUMMARY OF DETECTED CHEMICALS IN BACKGROUND SURFACE WATER SAMPLES[1]
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[2]	Frequency Of Detection[3]	Range Of Detected Concentrations[4] (mg/l)	Arithmetic Mean[5] (mg/l)
Barium	2/2	0.0224 - 0.0235	0.023
Calcium	3/3	29.2 - 35.9	32.4
Copper	1/3	ND - 0.0042	0.01
Iron	2/2	0.203 - 0.461	0.332
Magnesium	3/3	11 - 12.6	11.7
Manganese	2/2	0.0235 - 0.0673	0.045
Potassium	2/3	ND - 1.8	1.94
Selenium	1/3	ND - 0.0032	0.003
Sodium	3/3	6.21 - 7.53	3.46

Notes:
The determination of frequency of detections and the calculation of mean concentrations are performed in accordance with the procedures outlined in Risk Assessment Guidance For Superfund (RAGS), Volume 1 (USEPA, 1989a) and Guidance for Data Usability in Risk Assessment, Interim Final (USEPA, 1990).

[1] Based on chemical concentrations in surface water samples SW-1, SW-3, and SW-4.

[2] Constituent is listed if it was detected at a frequency of at least once in the environmental media. Only constituents qualified with an A, J, K, or L are considered detected.

[3] Frequency of Detection is the number of times a constituent is detected over the number of times a constituent was analyzed in each media subgroup. Data qualified with an N, B, JN or R are not counted in the determination of frequency of detection.

[4] ND = Not detected.

[5] Mean is the Arithmetic Mean where:
- Field duplicate and primary sample results are averaged for a given sample value
- The highest value of either the primary or reanalysis is used for a given sample
- One-half the SQL or CRDL is used as the result for data containing 'U' in its qualifier
- One-half the reported value is used for data qualified as K or L
- The full reported value is used for data qualified as A or J

TABLE 7
SUMMARY OF DETECTED CHEMICALS IN ONSITE SURFACE WATER SAMPLES[1]
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[2]	Frequency Of Detection[3]	Range Of Detected Concentrations[4] (mg/l)	Arithmetic Mean[5] (mg/l)
Aluminum	3/3	0.156 - 0.238	0.2
Barium	7/7	0.0114 - 0.0354	0.027
Calcium	8/8	27.4 - 50.7	40
Cyanide	1/8	ND - 0.0519	0.011
Iron	5/5	0.222 - 0.675	0.441
Magnesium	8/8	11.3 - 15.9	13.5
Manganese	8/8	0.0104 - 0.276	0.104
Potassium	8/8	1.11 - 4.09	2.27
Sodium	8/8	6.68 - 19.6	7.16
Vanadium	3/8	ND - 0.0048	0.017

Notes:

The determination of frequency of detections and the calculation of mean concentrations are performed in accordance with the procedures outlined in Risk Assessment Guidance For Superfund (RAGS), Volume 1 (USEPA, 1989a) and Guidance for Data Usability in Risk Assessment, Interim Final (USEPA, 1990).

[1] Based on chemical concentrations in surface water samples SW-6, SW-7, SW-8, SW-9, SW-10, SW-11, SW-12, and SW-13.

[2] Constituent is listed if it was detected at a frequency of at least once in the environmental media. Only constituents qualified with an A, J, K, or L are considered detected.

[3] Frequency of Detection is the number of times a constituent is detected over the number of times a constituent was analyzed in each media. Data qualified with an N, B, JN or R are not counted in the determination of frequency of detection.

[4] ND = Not detected.

[5] Mean is the Arithmetic Mean where:

Field duplicate and primary sample results are averaged for a given sample value
The highest value of either the primary or reanalysis is used for a given sample
One-half the SQL or CRDL is used as the result for data containing 'U' in its qualifier
One-half the reported value is used for data qualified as K or L
The full reported value is used for data qualified as A or J

TABLE 8
SUMMARY OF DETECTED CHEMICALS IN BACKGROUND SEDIMENT SAMPLES[1]
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[2]	Frequency Of Detection[3]	Range Of Detected Concentrations[4] (mg/kg)	Arithmetic Mean[5] (mg/kg)
Benzo(a)Anthracene	1/4	ND - 0.17	0.211
Benzo(a)Pyrene	1/4	ND - 0.11	0.196
Benzo(b)Fluoranthene	1/3	ND - 0.061	0.16
Benzo(k)Fluoranthene	1/3	ND - 0.079	0.166
Chrysene	1/4	ND - 0.13	0.201
Fluoranthene	1/4	ND - 0.26	0.234
Indeno(1,2,3-cd)Pyrene	1/4	ND - 0.088	0.191
Phenanthrene	1/4	ND - 0.087	0.191
Pyrene	1/4	ND - 0.19	0.216
Aluminum	4/4	10,600 - 24,200	14,300
Arsenic	4/4	3.2 - 10.7	5.28
Barium	4/4	56.8 - 102	75.7
Beryllium	2/4	ND -1.5	1.03
Calcium	4/4	4,330 - 7,040	5,525
Chromium	4/4	16.5 - 23.6	19.8
Cobalt	4/4	18 - 21.6	19.5
Copper	4/4	18.5 - 69.6	46.1
Iron	4/4	25,000 - 36,000	31,175
Lead	4/4	8.6 - 31.4	17.1
Magnesium	4/4	1,760 - 4,250	2,733
Manganese	4/4	601 - 1,650	915
Nickel	3/4	ND - 17.5	14.0
Potassium	1/4	ND - 1,430	873
Sodium	1/1	904 - 904	904
Vanadium	4/4	62.6 - 134	108
Zinc	4/4	61.8 - 90.5	74.7

Notes:
The determination of frequency of detections and the calculation of mean concentrations are performed in accordance with the procedures outlined in Risk Assessment Guidance For Superfund (RAGS), Volume 1 (USEPA, 1989a) and Guidance for Data Usability in Risk Assessment, Interim Final (USEPA, 1990).

[1] Based on chemical concentrations in sediment samples SED-1, SED-2, SED-3, and SED-4.

[2] Constituent is listed if it was detected at a frequency of at least once in the environmental media. Only constituents qualified with an A, J, K, or L are considered detected.

[3] Frequency of Detection is the number of times a constituent is detected over the number of times a constituent was analyzed in each media. Data qualified with an N, B, JN or R are not counted in the determination of frequency of detection.

[4] ND = Not detected.

[5] Mean is the Arithmetic Mean where:
Field duplicate and primary sample results are averaged for a given sample value
The highest value of either the primary or reanalysis is used for a given sample
One-half the SQL or CRDL is used as the result for data containing 'U' in its qualifier
One-half the reported value is used for data qualified as K or L
The full reported value is used for data qualified as A or J

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TABLE 9
SUMMARY OF DETECTED CHEMICALS IN ONSITE SEDIMENT SAMPLES[1]
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[2]	Frequency Of Detection[3]	Range Of Detected Concentrations[4] (mg/kg)	Arithmetic Mean[5] (mg/kg)
Benzo(a)Anthracene	4/10	ND - 0.1	0.173
Benzo(b)Fluoranthene	1/5	ND - 0.067	0.204
Chrysene	4/10	ND - 0.089	0.172
Fluoranthene	6/10	ND - 0.18	0.162
Phenanthrene	3/10	ND - 0.13	0.194
Pyrene	5/10	ND - 0.11	0.162
Aluminum	10/10	7,200 - 17,300	11,061
Arsenic	10/10	1.55 - 4.4	2.64
Barium	10/10	42.3 - 115	73.3
Beryllium	5/10	ND - 1.3	0.91
Cadmium	3/10	ND - 4.7	1.82
Calcium	10/10	3,350 - 12,400	6,505
Chromium	10/10	9.1 - 35	20
Cobalt	10/10	11.2 - 30.7	16.6
Copper	10/10	15.4 - 67.9	38.9
Iron	10/10	16,500 - 36,300	27,290
Lead	10/10	5.9 - 19.7	9.72
Magnesium	10/10	2,020 - 6,920	4,299
Manganese	10/10	758 - 1,309	931.2
Mercury	2/9	ND - 0.24	0.1
Nickel	10/10	11.3 - 34.5	16.6
Potassium	5/10	ND - 1,250	778
Vanadium	10/10	41.9 - 138	87.2
Zinc	10/10	50.4 - 110	72.6

Notes:
The determination of frequency of detections and the calculation of mean concentrations are performed in accordance with the procedures outlined in Risk Assessment Guidance For Superfund (RAGS), Volume 1 (USEPA, 1989a) and Guidance for Data Usability in Risk Assessment, Interim Final (USEPA, 1990).

[1] Based on chemical concentrations in sediment samples SED-5, SED-6, SED-7, SED-8, SED-9, SED-10, and SED-11.

[2] Constituent is listed if it was detected at a frequency of at least once in the environmental media. Only constituents qualified with an A, J, K, or L are considered detected.

[3] Frequency of Detection is the number of times a constituent is detected over the number of times a constituent was analyzed in each media. Data qualified with an N, B, JN or R are not counted in the determination of frequency of detection.

[4] ND = Not detected.

[5] Mean is the Arithmetic Mean where:
- Field duplicate and primary sample results are averaged for a given sample value
- The highest value of either the primary or reanalysis is used for a given sample
- One-half the SQL or CRDL is used as the result for data containing 'U' in its qualifier
- One-half the reported value is used for data qualified as K or L
- The full reported value is used for data qualified as A or J

TABLE 10
SUMMARY OF DETECTED CHEMICALS IN LEACHATE LAGOON WATER SAMPLES[1]
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[2]	Frequency Of Detection[3]	Range Of Detected Concentrations[4] (mg/l)	Arithmetic Mean[5] (mg/l)
1,1-Dichloroethane	1/2	ND - 0.004	0.008
1,1-Dichloroethene	1/2	ND - 0.012	0.011
2-Butanone	2/2	0.16 - 0.19	0.175
4-Methyl-2-Pentanone	1/2	ND - 0.028	0.02
Acetone	1/1	0.1 - 0.1	0.1
Benzene	2/2	0.014 - 0.021	0.018
Chlorobenzene	2/2	0.003 - 0.01	0.007
Ethylbenzene	2/2	0.054 - 0.079	0.067
Tetrachloroethene	2/2	0.003 - 0.0085	0.006
Toluene	2/2	0.24 - 0.37	0.305
Total 1,2-Dichloroethene	2/2	0.045 - 0.075	0.06
Total Xylenes	2/2	0.15 - 0.24	0.195
Trichloroethene	2/2	0.006 - 0.0165	0.011
Vinyl Chloride	2/2	0.007 - 0.011	0.009
1,2-Dichlorobenzene	1/2	ND - 0.003	0.004
1,4-Dichlorobenzene	2/2	0.003 - 0.0075	0.006
2,4-Dimethylphenol	1/2	ND - 0.001	0.003
2-Methylphenol	2/2	0.002 - 0.002	0.002
4-Methylphenol	2/2	0.001 - 0.17	0.091
Diethylphthalate	1/1	0.001 - 0.001	0.001
Isophorone	1/2	ND - 0.0015	0.006
Naphthalene	1/2	ND - 0.003	0.004
Phenol	1/2	ND - 0.03	0.018

TABLE 10
SUMMARY OF DETECTED CHEMICALS IN LEACHATE LAGOON WATER SAMPLES[1]
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[2]	Frequency Of Detection[3]	Range Of Detected Concentrations[4] (mg/l)	Arithmetic Mean[5] (mg/l)
Barium	2/2	0.384 - 0.623	0.503
Calcium	2/2	124 - 173	149
Chromium	1/2	ND - 0.0138	0.009
Cobalt	1/1	0.0118 - 0.0118	0.012
Iron	2/2	9.61 - 35.4	22.5
Magnesium	2/2	63.2 - 86.5	74.9
Manganese	2/2	4.45 - 5.83	5.14
Nickel	1/1	0.0311 - 0.0311	0.031
Potassium	2/2	28.3 - 38.5	33.4
Sodium	2/2	201 - 275	238

Notes:

The determination of frequency of detections and the calculation of mean concentrations are performed in accordance with the procedures outlined in Risk Assessment Guidance For Superfund (RAGS), Volume 1 (USEPA, 1989a) and Guidance for Data Usability in Risk Assessment, Interim Final (USEPA, 1990).

[1] Based on chemical concentrations in lagoon water samples L1-MH1 and L2-MH1.

[2] Constituent is listed if it was detected at a frequency of at least once in the environmental media. Only constituents qualified with an A, J, K, or L are considered detected.

[3] Frequency of Detection is the number of times a constituent is detected over the number of times a constituent was analyzed in each media subgroup. Data qualified with an N, B, JN or R are not counted in the determination of frequency of detection.

[4] ND = Not detected.

[5] Mean is the Arithmetic Mean where:
- Field duplicate and primary sample results are averaged for a given sample value
- The highest value of either the primary or reanalysis is used for a given sample
- One-half the SQL or CRDL is used as the result for data containing 'U' in its qualifier
- One-half the reported value is used for data qualified as K or L
- The full reported value is used for data qualified as A or J

TABLE 11
SUMMARY OF DETECTED CHEMICALS IN LEACHATE SEEP WATER SAMPLES[1]
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[2]	Frequency Of Detection[3]	Range Of Detected Concentrations[4] (mg/l)	Arithmetic Mean[5] (mg/l)
Acetone	1/3	ND - 0.016	0.009
Benzene	2/6	ND - 0.008	0.006
Chlorobenzene	3/6	ND - 0.0145	0.006
Chloroethane	1/6	ND - 0.0155	0.007
Ethylbenzene	2/6	ND - 0.087	0.019
Toluene	3/6	ND - 0.005	0.004
Total Xylenes	2/6	ND - 0.15	0.035
1,4-Dichlorobenzene	1/2	ND - 0.0085	0.007
2-Methylnaphthalene	2/2	0.002 - 0.002	0.002
4-Chloro-3-Methylphenol	1/2	ND - 0.002	0.004
4-Methylphenol	1/2	ND - 0.001	0.003
Naphthalene	2/2	0.011 - 0.013	0.012
bis(2-Ethylhexyl)Phthalate	1/2	ND - 0.001	0.003

TABLE 11
SUMMARY OF DETECTED CHEMICALS IN LEACHATE SEEP WATER SAMPLES[1]
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected[2]	Frequency Of Detection[3]	Range Of Detected Concentrations[4] (mg/l)	Arithmetic Mean[5] (mg/l)
Aluminum	2/2	0.41 - 4.04	2.23
Arsenic	2/2	0.0091 - 0.0166	0.006
Barium	2/2	0.266 - 0.453	0.36
Cadmium	2/2	0.0022 - 0.0034	0.001
Calcium	2/2	46 - 121	83.5
Chromium	2/2	0.0128 - 0.0249	0.009
Cobalt	1/1	0.0313 - 0.0313	0.031
Copper	2/2	0.0042 - 0.0202	0.012
Iron	2/2	10.5 - 24.7	17.6
Lead	2/2	0.0156 - 0.0174	0.017
Magnesium	2/2	23.2 - 153	88.1
Manganese	2/2	0.88 - 2.26	1.57
Nickel	1/1	0.0997 - 0.0997	0.1
Potassium	2/2	49 - 345	197
Sodium	2/2	132 - 954	543
Vanadium	2/2	0.0079 - 0.0203	0.014
Zinc	2/2	0.0974 - 0.213	0.131

Notes:

The determination of frequency of detections and the calculation of mean concentrations are performed in accordance with the procedures outlined in Risk Assessment Guidance For Superfund (RAGS), Volume 1 (USEPA, 1989a) and Guidance for Data Usability In Risk Assessment, Interim Final (USEPA, 1990).

[1] Based on chemical concentrations in leachate seep water samples L1-EL, L1-WL, L2-EL, L2-WL, L3-EL, L3-WL.

[2] Constituent is listed if it was detected at a frequency of at least once in the environmental media. Only constituents qualified with an A, J, K, or L are considered detected.

[3] Frequency of Detection is the number of times a constituent is detected over the number of times a constituent was analyzed in each media. Data qualified with an N, B, JN or R are not counted in the determination of frequency of detection.

[4] ND = Not detected.

[5] Mean is the Arithmetic Mean where:
- Field duplicate and primary sample results are averaged for a given sample value
- The highest value of either the primary or reanalysis is used for a given sample
- One-half the SQL or CRDL is used as the result for data containing 'U' in its qualifier
- One-half the reported value is used for data qualified as K or L
- The full reported value is used for data qualified as A or J

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TABLE 12
SUMMARY OF DETECTED CHEMICALS
IN AIR MONITORING SAMPLES
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected	Passive Vents			Ambient Air 8-Hour Composite (1)			Ambient Air 24-Hour Composite (1)		
	Frequency of Detection (2)	Range of Detected Concentrations (mg/m3) (3)	Arithmetic Mean (mg/m3) (4)	Frequency of Detection (2)	Range of Detected Concentrations (mg/m3) (3)	Arithmetic Mean (mg/m3) (4)	Frequency of Detection (2)	Range of Detected Concentrations (mg/m3) (3)	Arithmetic Mean (mg/m3) (4)
Acetone	0/3	ND	ND	0/2	ND	ND	1/7	ND-0.030	0.015
Benzene	2/3	ND-0.92	0.617	0/2	ND	ND	0/7	ND	ND
Benzyl Chloride	0/3	ND	ND	0/2	ND	ND	0/7	ND	ND
Chlorobenzene	1/3	ND-1.2	0.735	0/2	ND	ND	0/7	ND	ND
Chloroethane	2/3	ND-1.6	1.117	0/2	ND	ND	0/7	ND	ND
Dichlorodifluoromethane	2/3	ND-6.6	2.684	0/2	ND	ND	0/7	ND	ND
cis-1,2-Dichloroethene	2/3	ND-4.3	1.494	0/2	ND	ND	0/7	ND	ND
trans-1,2 Dichloroethene	0/3	ND	ND	0/2	ND	ND	0/7	ND	ND
1,2-Dichloro-1,1,2,2-Tetrafluoroetha	1/3	ND-0.42	0.677	0/2	ND	ND	0/7	ND	ND
4-Ethyl Toluene	3/3	0.55-34.0	13.217	0/2	ND	ND	0/7	ND	ND
Ethylbenzene	3/3	1.6-140.0	55.867	0/2	ND	ND	0/7	ND	ND
2-Hexanone	0/3	ND	ND	0/2	ND	ND	1/7	ND-0.040	0.013
Hydrogen Sulfide	2/3	ND-18.04	6.847	0/2	ND	ND	0/7	ND	ND
Toluene	2/3	ND-68.0	28.686	1/2	ND-0.040	0.030	2/7	ND-0.009	0.005
Trichloroethene	2/3	ND-2.1	0.782	0/2	ND	ND	0/7	ND	ND
Trichlorofluoromethane	0/3	ND	ND	0/2	ND	ND	0/7	ND	ND
1,1,2-Trichloro-1,2,2-Trifluoroethane	0/3	ND	ND	0/2	ND	ND	0/7	ND	ND
1,2,4-Trimethylbenzene	3/3	0.52-21.0	9.073	0/2	ND	ND	0/7	ND	ND
1,3,5-Trimethylbenzene	3/3	0.4-12.0	5.000	0/2	ND	ND	0/7	ND	ND
Vinyl Chloride	3/3	0.087-15.0	5.929	0/2	ND	ND	0/7	ND	ND
Total Xylenes	3/3	18.0-330.0	129.667	0/2	ND	ND	2/7	ND-0.011	0.006

Notes:
(1) Combination of Leachate Seep and Lagoon Station 8-hour samples.
(2) Frequency of Detection is the number of times a constituent was detected over the number of times a constituent was analyzed.
(3) ND = Not detected
(4) Not detected results were not used in the calculation of the mean because reporting limits varied.

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TABLE 13
COMPARISON OF CHEMICALS DETECTED IN GROUNDWATER WITH USEPA RISK-BASED SCREENING CONCENTRATIONS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected	Background (Upgradient) Maximum Concentration (mg/l)	On-site (Downgradient) Maximum Concentration (1) (mg/l)	Off-Site (Residential) Maximum Concentration (mg/l)	USEPA Region III Risk-Based Concentration (2) (mg/l)
Organics				
Acetone	ND (3)	0.006	ND	0.37
Benzene	ND	0.005	ND	0.000087
Bromomethane	0.014 (4)	ND	ND	0.00087
Carbon Disulfide	ND	0.003	ND	0.0021
Chlorobenzene	ND	0.022	ND	0.0039
Chloroethane	ND	0.006	ND	0.071
Chloroform	ND	ND	0.0006	0.00015
Chloromethane	0.02 (4)	0.006	ND	0.0014
Di-n-butylphthalate	ND	0.001	ND	0.37
1,4-Dichlorobenzene	ND	0.007	ND	0.00044
1,1-Dichloroethane	ND	0.008	ND	0.081
1,2-Dichloroethane	0.0005 (4)	0.002	0.002	0.00012
1,1-Dichloroethene	ND	0.001	ND	0.000044
Total 1,2-Dichloroethene	ND	0.026	ND	0.0055
bis(2-Ethylhexyl)Phthalate	ND	0.008 (4)	ND	0.0048
Hexachloroethane	ND	0.004	ND	0.00061
Naphthalene	ND	0.005	ND	0.15
Toluene	ND	ND	0.0009	0.075
1,1,2-Trichloroethane	ND	ND	0.0006	0.00019
Trichloroethene	ND	0.005	ND	0.0016
Vinyl Chloride	ND	0.05	ND	0.000019
Inorganics				
Aluminum	58.3	55.7	ND	11
Arsenic	0.0089	0.01	0.006	0.000038
Barium	0.173	0.62	0.028	0.26
Beryllium	0.005	2.4E-03	ND	0.000016
Cadmium	0.013	0.0144	ND	0.0018
Chromium	0.098	0.065	ND	3.7 (6)
Cobalt	0.028	0.03	ND	0.22
Copper	0.272	0.152	0.0311	0.14
Cyanide	4.5E-04	ND	ND	0.073
Lead	0.017	0.0934	ND	0.015 (5)
Manganese	1.24	6.67	ND	0.018
Mercury	ND	2.5E-04	ND	0.0011
Nickel	0.076	0.06	0.0418	0.073
Vanadium	0.156	0.11	ND	0.026
Zinc	0.136	0.236	0.01	1.1

Notes:
Data qualified B,K, or L (as defined by USEPA Region III guidance for data validation) are not included in the selection of COPCs.
Maximum concentrations > risk-based screening concentrations are selected as COPCs and are shaded in this table.
(1) Based on chemical concentrations in monitoring wells C-5, G-1, G-4, G-6, G-12, G-13, MP-14S, and MP-14D.
(2) From "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening" (USEPA, 1994a) and were based on a conservative HQ of 0.1.
(3) ND = Not Detected
(4) These chemicals are not selected as COPCs(See Section 4.2.1 of text for discussion).
(5) USEPA Action Level for lead in drinking water (USEPA, 1993b).
(6) Value represents Chromium III.

TABLE 14
COMPARISON OF CHEMICALS DETECTED IN SURFACE SOIL WITH USEPA RISK-BASED SCREENING CONCENTRATIONS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected	Background Soil Maximum Concentration (mg/kg)	On-site Soil Maximum Concentration (mg/kg)	USEPA Region III Risk-Based Concentration (1) (mg/kg)
Organics			
Acenaphthene	ND (2)	0.38	6,100
Acetone	ND	0.11	10,000
Anthracene	ND	0.655	31,000
Benzo(a)Anthracene	ND	1.85	3.9
Benzo(a)Pyrene	ND	1.205	0.39
Benzo(b)Fluoranthene	ND	0.15	3.9
Benzo(g,h,i)Perylene	ND	0.63	4,100
Benzo(k)Fluoranthene	ND	0.068	39
2-Butanone	ND	0.014	61,000
Butylbenzylphthalate	0.044	0.063	20,000
Carbazole	ND	0.37	140
Chlorobenzene	ND	0.002	2,000
Chloroform	ND	0.006	470
Chrysene	0.047	1.5	390
Di-n-Octyl Phthalate	ND	0.054	2,000
Dibenz(a,h)Anthracene	ND	0.32	0.39
Dibenzofuran	ND	0.26	310
1,4-Dichlorobenzene	ND	0.12	120
Ethylbenzene	ND	0.037	10,000
Fluoranthene	0.068	3.15	4,100
Fluorene	ND	0.46	4,100
Indeno(1,2,3-cd)Pyrene	ND	0.58	3.9
4-Methyl-2-Pentanone	ND	0.004	5,100
2-Methylnaphthalene	ND	0.12	4,100
Naphthalene	ND	0.4	4,100
Di-n-Octyl Phthalate	ND	0.054	2,000
Pentachlorophenol	ND	0.11	24
Phenanthrene	ND	2.9	4,100(4)
Phenol	ND	0.12	61,000
Pyrene	0.041	2.7	3,100
Toluene	ND	0.18	20,000
Total Xylenes	ND	0.073	200,000
Aroclor-1248	ND	0.27	0.37

TABLE 14
COMPARISON OF CHEMICALS DETECTED IN SURFACE SOIL WITH USEPA RISK-BASED SCREENING CONCENTRATIONS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected	Background Soil Maximum Concentration (mg/kg)	On-site Soil Maximum Concentration (mg/kg)	USEPA Region III Risk-Based Concentration (1) (mg/kg)
Inorganics			
Aluminum	26,600	33,400	300,000
Arsenic	ND	30.9	1.6
Barium	151	933	7,200
Beryllium	1.5	2	0.67
Cadmium	ND	9.1	51
Chromium	91.8	1,180	7,800
Cobalt	34.8	37	470
Copper	408	143	3,800
Lead	37.4	48.4	400 (3)
Manganese	ND	6,030	510
Mercury	ND	0.26	31
Nickel	37.3	771	2,000
Selenium	ND	66.2	510
Silver	ND	0.67	510
Vanadium	152	137	720
Zinc	151	332	31,000

Notes:
Data qualified B,K, or L (as defined by USEPA Region III guidance for data validation) are not included in the selection of COPCs.
Maximum concentrations > risk-based screening concentrations are selected as COPCs and are shaded in this table.
(1) From "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening" (USEPA, 1994a) and based on a conservative HQ of 0.1.
(2) ND = Not Detected
(3) USEPA recommended screening level for lead in soil for residential land use (USEPA, 1994e).
(4) Naphthalene concentration is used as a surrogate based on toxicological structure-activity relationship.

TABLE 15
COMPARISON OF CHEMICALS DETECTED IN SURFACE WATER WITH USEPA RISK-BASED SCREENING CONCENTRATIONS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected	Background Surface Water Maximum Concentfation (mg/l)	On-site Surface Water Maximum Concentration (mg/l)	Calculated Risk-Based Concentration (1) (mg/l)
Inorganics			
Aluminum	ND (2)	0.238	24,000
Barium	0.0235	0.0354	580
Copper	0.0042	ND	310
Cyanide	ND	0.0519	170
Manganese	0.0673	0.284	42
Selenium	0.0032	ND	42
Vanadium	ND	0.0048	58

Notes:
Data qualified B,K, or L (as defined by USEPA Region III guidance for data validation) are not included in the selection of COPCs.
(1) See Section 4.0 of text for the methodology of calculated risk-based values.
(2) ND = Not detected

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TABLE 16
COMPARISON OF CHEMICALS DETECTED IN SEDIMENT WITH USEPA RISK-BASED SCREENING CONCENTRATIONS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected	Background Sediment Maximum Concentration (mg/kg)	On-site Sediment Maximum Concentration (mg/kg)	USEPA Region III Risk-Based Concentration (1) (mg/kg)
Organics			
Benzo(a)Anthracene	0.17	0.1	3.9
Benzo(a)Pyrene	0.11	ND (2)	0.39
Benzo(b)Fluoranthene	0.061	0.067	3.9
Benzo(k)Fluoranthene	0.079	ND	39
Chrysene	0.13	0.089	390
Fluoranthene	0.26	0.18	4,100
Indeno(1,2,3-cd)Pyrene	0.088	ND	3.9
Phenanthrene	0.087	0.13	4,100 (3)
Pyrene	0.19	0.11	3,100
Inorganics			
Aluminum	24,200	17,300	300,000
Arsenic	10.7	4.4	1.6
Barium	102	115	7,200
Beryllium	1.5	1.3	0.67
Cadmium	ND	4.7	51
Chromium	23.6	35	7,800
Cobalt	21.6	30.65	470
Copper	69.6	67.9	3,800
Lead	31.4	19.7	400 (4)
Manganese	1,650	1,309	510
Nickel	17.5	34.5	2,000
Vanadium	134	138	720
Zinc	90.5	110	31,000

Notes:

Data qualified B,K, or L (as defined by USEPA Region III guidance for data validation) are not included in the selection of COPCs.

Maximum concentrations > risk-based screening concentrations are shaded in this table.

(1) From "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening" (USEPA, 1994a) and based on a conservative HQ of 0.1.

(2) ND = Not Detected

(3) Naphthalene concentration is used as a surrogate based on toxicological structure-activity relationship.

(4) USEPA recommended screening level for lead in soil for residential land use (USEPA, 1994e).

TABLE 17
COMPARISON OF CHEMICALS DETECTED IN LEACHATE WITH USEPA RISK-BASED SCREENING CONCENTRATIONS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected	Leachate Lagoon Water Maximum Concentration (mg/l)	Leachate Seep Water Maximum Concentration (mg/l)	Calculated Risk-Based Concentration (1) (mg/l)
Organics			
Acetone	0.1	0.018	830
Benzene	0.029	0.008	0.12
2-Butanone	0.22	ND (2)	5,200
4-Chloro-3-Methylphenol	ND	0.002	NA (3)
Chlorobenzene	0.017	0.009	4
Chloroethane	ND	0.018	420
1,1-Dichloroethane	0.004	ND	98
1,1-Dichloroethene	0.012	ND	0.035
1,2-Dichlorobenzene	0.003	ND	11
1,4-Dichlorobenzene	0.008	0.009	0.21
Diethylphthalate	0.001	ND	1,300
2,4-Dimethylphenol	0.001	ND	11
Ethylbenzene	0.083	0.087	11
bis(2-Ethylhexyl)Phthalate	ND	0.001	0.56
Isophorone	0.002	ND	89
4-Methyl-2-Pentanone	0.028	ND	14
2-Methylnaphthalene	ND	0.002	4.4
2-Methylphenol	0.002	ND	42
4-Methylphenol	0.18	0.001	4.3
Naphthalene	0.003	0.013	4.4
Phenol	0.03	ND	980
Tetrachloroethene	0.009	ND	0.12
Toluene	0.41	0.005	1.7
Total Xylenes	0.25	0.015	17,000
Trichloroethene	0.024	ND	0.15
Vinyl Chloride	0.011	ND	0.18
Inorganics			
Aluminum	ND	4.04	24,000
Barium	0.823	0.453	580
Chromium (III)	0.0138	ND	52,000
Cobalt	0.0118	0.0313	3,100
Copper	ND	0.0202	310
Lead	ND	0.0174	NA
Manganese	5.83	2.28	42
Nickel	0.0311	0.0997	1,700
Vanadium	ND	0.0203	58
Zinc	ND	0.213	4,200

Notes:
Data qualified B,K, or L (as defined by USEPA Region III guidance for data validation) are not included in the selection of COPCs.
Maximum concentrations > risk-based screening concentrations are shaded in this table.
(1) See Section 4.0 of text for the methodology of calculated risk-based values.
(2) ND = Not Detected
(3) NA = Not Available

TABLE 18
COMPARISON OF CHEMICALS DETECTED IN AIR WITH USEPA RISK-BASED SCREENING CONCENTRATIONS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituents Detected	Passive Vents Maximum Concentration (mg/m3)	8-Hour Composite Ambient Air Maximum Concentration (mg/m3)	24-Hour Composite Ambient Air Maximum Concentration (mg/m3)	USEPA Region III Risk-Based Concentration (1) (mg/m3)
Acetone	ND (2)	ND	0.030	0.037
Benzene	0.92	ND	ND	0.000052
Chlorobenzene	1.2	ND	ND	0.0021
Chloroethane	1.6	ND	ND	1.0
Dichlorodifluoromethane	6.6	ND	ND	0.021
cis-1,2-Dichloroethene	4.3	ND	ND	0.0037
1,2-Dichloro-1,1,2,2-Tetrafluoroethane	0.42	ND	ND	NA (3)
4-Ethyl Toluene	34	ND	ND	NA
Ethylbenzene	140	ND	ND	0.1
2-Hexanone	ND	ND	0.04	0.1 (4)
Hydrogen Sulfide	18.04	ND	ND	0.000094
Toluene	68	0.040	0.0085	0.042
Trichloroethene	2.1	ND	ND	0.001
1,2,4-Trimethylbenzene	21	ND	ND	0.00018
1,3,5-Trimethylbenzene	12	ND	ND	0.00015
Vinyl Chloride	15	ND	ND	0.000021
Total Xylenes	330	ND	0.011	0.73

Notes:
Maximum concentrations > risk-based screening concentrations are selected as COPCs and are shaded in this table.
(1) From "Selecting Exposure Routes and Contaminants by Risk-Based Screening (USEPA, 1994a)
and based on a conservative HQ of 0.1.
(2) ND = Not Detected
(3) NA = Not Available
(4) 2-Butanone is used as a surrogate based on a toxicological structure-activity relationship.

TABLE 19
SYSTEMIC TOXICITY DATA FOR CHEMICALS OF POTENTIAL CONCERN
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Chemicals	Oral RfD (mg/kg-day)	Oral RfD(a,b) (basis/source)	Confidence Level (a)	Critical Effect (a)	Uncertainty Factor	Modifying Factors	Inhalation RfD (mg/kg-day)	Inhalation RfD (a,b) (basis/source)	Confidence Level (a)	Critical Effect (a)	Uncertainty Factor	Modifying Factors
Aluminum	1.0E+00	food/ECAO (c)	Medium	neurotoxicity	—	—	ND	—	—	—	—	—
Arsenic	3.0E-04	water/IRIS	Medium	hyperpigmentation, keratosis	3	1	ND	—	—	—	—	—
Barium	7.0E-02	water/IRIS	Medium	increased blood pressure	3	1	1.4E-04	air/HEAST	—	reproductive effects	1000	1
Cobalt	6.0E-02	ECAO (c)	—	—	—	—	—	—	—	—	—	—
Benzene	ND	—	—	—	—	—	1.7E-03	air/ECAO	—	—	—	—
Benzo(a)pyrene	ND	—	—	—	—	—	ND	—	—	—	—	—
Beryllium	5.0E-03	water/IRIS	Low	no adverse effects	100	1	ND	—	—	—	—	—
Bromomethane	1.4E-03	gavage/IRIS	Medium	epithelial hyperplasia of the forestomach	1000	1	1.4E-03	air/IRIS	Medium	nasal cavity lesions	100	1
Cadmium	5.0E-04	water/IRIS	High	significant proteinuria	10	1	ND	—	—	—	—	—
Carbon Disulfide	1.0E-01	air/IRIS	Medium	fetal toxicity malformations	100	1	2.9E-03	air/HEAST	—	—	—	—
Chlorobenzene	2.0E-02	oral/IRIS	—	histopathological changes in liver	1000	1	5.7E-03	air/HEAST	—	—	—	—
Chloroethane	4.0E-01	ECAO (c)	—	—	—	—	2.86E+00	air/IRIS	Medium	delayed fetal ossification	300	1
Chloroform	1.0E-02	oral/IRIS	Medium	fatty cyst formation in liver	1000	1	ND	—	—	—	—	—
Chloromethane	ND	—	—	—	—	—	ND	—	—	—	—	—
Copper	3.7E-02	diet/HEAST		G.I. irritation	—	—	ND	—	—	—	—	—
1,4-Dichlorobenzene	ND	—	—	—	—	—	2.3E-01	air/IRIS	Medium	increased liver weight	100	1
Dichlorodifluoromethane	2.0E-01	feed/IRIS	Medium	decreased body weight	100	1	5.71E-02	air/HEAST	—	—	—	—
1,2-Dichloroethane	ND	—	—	—	—	—	2.86E-03	air/ECAO	—	—	—	—
1,1-Dichloroethane	9.0E-03	water/IRIS	Medium	hepatic lesions	1000	1	ND	—	—	—	—	—
cis-1,2-Dichloroethene	1.0E-02	gavage/HEAST	—	decreased hematocrit	—	—	ND	—	—	—	—	—
Total 1,2-Dichloroethene	9.0E-03	water/HEAST	—	liver lesions	—	—	ND	—	—	—	—	—
1,2-Dichloropropane	ND	—	—	—	—	—	1.0E-03	air/IRIS	Medium	hyperplasia of the nasal mucosa	300	1

TABLE 19
SYSTEMIC TOXICITY DATA FOR CHEMICALS OF POTENTIAL CONCERN
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Chemicals	Oral RfD (mg/kg-day)	Oral RfD(a,b) (basis/source)	Confidence Level (a)	Critical Effect (a)	Uncertainty Factor	Modifying Factors	Inhalation RfD (mg/kg-day)	Inhalation RfD (a,b) (basis/source)	Confidence Level (a)	Critical Effect (a)	Uncertainty Factor	Modifying Factors
1,2-Dichloro-1,1,2,2-Tetrafluoroethane	ND	—	—	—	—	—	ND	—	—	—	—	—
Ethylbenzene	1.0E-01	gavage/IRIS	Low	liver, kidney toxicity	1000	1	2.86E-01	air/IRIS	Low	developmental toxicity	300	1
bis(2-Ethylhexyl)Phthalate	2.0E-02	diet/IRIS	Medium	increased relative liver weight	1000	1	ND	—	—	—	—	—
4-Ethyl Toluene	ND	—	—	—	—	—	ND	—	—	—	—	—
Hexachloroethane	1.0E-03	diet/IRIS	Medium	atrophy and degeneration of the renal tubes	1000	1	ND	—	—	—	—	—
Hydrogen Sulfide	3.0E-03	diet/IRIS	Low	G.I. disturbance	1000	1	2.57E-04	air/IRIS	Medium	nasal mucosa inflammation	1000	1
Manganese	5.0E-03	diet/IRIS	Medium	CNS effects	1	1	1.43E-05	air/IRIS	Medium	impairment of neurobehavioral function	1000	1
Nickel	2.0E-02	diet/IRIS	Low	decreased body and organ weights	300	1	NA	—	—	—	—	—
N-Nitroso-Di-N-Propylamine	ND	—	—	—	—	—	ND	—	—	—	—	—
1,1,2-Trichloroethane	4.0E-03	water/IRIS	Medium	clinical serum chemistry	1000	1	ND	—	—	—	—	—
Toluene	2.0E-01	gavage/IRIS	Medium	changes in liver, kidney weights	1000	1	1.14E-01	air/HEAST	Medium	neurological effects	300	1
Trichloroethene	6.0E-03	ECAO (c)	—	—	—	—	ND	—	—	—	—	—
1,2,4-Trimethylbenzene	5.0E-04	ECAO (c)	—	—	—	—	ND	—	—	—	—	—
1,3,5-Trimethylbenzene	4.0E-04	ECAO (c)	—	—	—	—	ND	—	—	—	—	—
Vanadium	7.0E-03	water/HEAST	—	none observed	100	—	ND	—	—	—	—	—
Vinyl Chloride	ND	—	—	—	—	—	ND	—	—	—	—	—
Total Xylenes	2.0E+00	gavage/IRIS	Medium	hyperactivity, decreased body weight, increased mortality	100	1	ND	—	—	—	—	—

NOTES:
(a) Integrated Risk Information Systems (IRIS, USEPA 1994b)
(b) Health Effects Assessment Summary Tables (HEAST, USEPA 1993)
(c) Environmental Criteria Assessment Office
ND = Not determined
NA = Not available
"—" = Not applicable

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TABLE 20

CARCINOGENIC TOXICITY DATA
FOR CHEMICALS OF POTENTIAL CONCERN
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Chemicals	Weight-of-Evidence Classification	Type of Cancer	Oral CSF (mg/kg-day)^-1	Inhalation CSF (mg/kg-day)^-1
Arsenic	A	lung, skin	1.7E+00(a,b)	1.51E+01 (a)
Benzene	A	leukemia	2.9E-02(a)	2.9E-02(a)
Benzo(a)pyrene	B2	forestomach, squamous cell papillomas	7.3E+00(a)	6.1E+00(c)
Beryllium	B2	lung, osteosarcomas	4.3E+00(a)	8.4E+00(a)
Cadmium	B1	lung	NA	6.3E+00(a)
Chloroform	B2	liver,kidney	6.1E-03(a)	8.1E-02(a)
Chloromethane	C	kidney	1.3E-02(c)	6.3E-03(c)
1,4-Dichlorobenzene	B2	liver tumors	2.4E-02(c)	ND
1,2-Dichloroethane	B2	multiple tumor types, lung papillomas	9.1E-02(a)	9.1E-02(a)
1,1-Dichloroethene	C	tumors	6.0E-01(a)	1.8E-01(a)
bis(2-Ethylhexyl)Phthalate	B2	liver	1.4E-02(a)	ND
Hexachloroethane	C	carcinomas	1.4E-02(a)	1.4E-02(a)
Lead	B2	ND	ND	ND
1,1,2-Trichloroethane	C	hepatocellular, pheochromocytomas	5.7E-02(a)	5.6E-02(a)
Trichloroethene	C-B2(d)	—	1.1E-02(e)	6.0E-03(e)
Vinyl Chloride	A	lung, liver	1.9E+00(c)	3.0E-01(c)

NOTES:
(a) Integrated Risk Information Systems (IRIS, USEPA 1994b)
(b) Based on proposed unit risk for arsenic of 5E-05ug/L (IRIS, USEPA 1994b)
(c) Health Affects Assessment Summary Tables (HEAST, USEPA 1993)
(d) Under review by USEPA
(e) Environmental Criteria and Assessment Office (ECAO)
NA = Not applicable
ND = Not determined

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TABLE 21

DERMALLY ADJUSTED CANCER SLOPE FACTORS AND REFERENCE DOSES FOR CHEMICALS DETECTED IN GROUNDWATER BERKS LANDFILL BERKS COUNTY, PENNSYLVANIA

Chemicals	G.I. Absorption Efficiency	Reference No.	Adjusted Dermal CSF(a) $(mg/kg/day)^{-1}$	Adjusted RfD(b) (mg/kg/day)
Benzene	1.00	1	2.90E-02	ND
Bromomethane	1.00	7	ND(c)	1.4E-03
Carbon Disulfide	0.63	3	ND	6.30E-02
Chlorobenzene	0.31	1	ND	6.2E-03
Chloroform	1.00	3	6.10E-03	1.00E-02
Chloromethane	1.00	7	1.3E-02	ND
1,4-Dichlorobenzene	1.00	2	2.4E-02	ND
1,2-Dichloroethane	1.00	2	9.1E-02	ND
1,1-Dichloroethene	1.00	5	6.0E-01	9.0E-03
Total 1,2-Dichloroethene	1.00	7	ND	9.0E-03
bis(2-Ethylhexyl)Phthalate	1.00	8	1.40E-02	2.00E-02
Hexachloroethane	1.00	7	1.4E-02	1.0E-03
Trichloroethene	0.98	1	1.12E-02	5.88E-03
1,1,2-Trichloroethane	0.81	1	7.04E-02	3.24E-03
Vinyl Chloride	1.00	2	1.90E+00	ND
Aluminum	0.15	6	ND	1.5E-01
Arsenic	0.60	2	2.8E+00	1.8E-04
Barium	0.5	2	ND	3.5E-02
Beryllium	0.01	3	4.30E+02	5.00E-05
Cadmium	0.5	6	ND	2.5E-04
Copper	0.97	2	ND	3.59E-02
Manganese	0.04	4	ND	2.00E-04
Nickel	0.10	2	ND	2.00E-03
Vanadium	1.00	2	ND	7.00E-03

NOTES:
(a) Dermal slope factors are calculated by dividing the oral slope factor by the G.I. absorption factor.
(b) Dermal reference doses are calculated by multiplying the oral RfD by the G.I. absorption factor.
(c) ND = Not Determined

References:

1. Agency for Toxic Substances and Disease Registry (ATSDR), 1989, "Toxicological Profile for Specified Compound," Draft Report.
2. USEPA, 1987, "Health Advisory for Specified Compound, Criteria and Standards Division, Office of Drinking Water, Washington, D.C.
3. Agency for Toxic Substances and Disease Registry (ATSDR), 1990, "Toxicological Profile for Specified Compound," Draft Report.
4. USEPA, 1984, "Health Effects, Assessment for Manganese," Office of Health and Environmental Assessment, Cincinnati, Ohio.
5. Agency for Toxic Substances and Disease Registry (ASTDR), 1993, "Toxicological Profile for Specified Compound," Draft Report.
6. Carson, et al., 1987, "Toxicology and Biological Monitoring of Metals in Humans," Lewis Publishers, Inc., Chelsea, MI.
7. One hundred percent absorption is assumed in this assessment based on analogy to other similar molecular weight organic compounds.
8. Agency for Toxic Substances and Disease Registry (ATSDR), 1992, "Toxicological Profile for Specified Compound," Draft Report.

TABLE 22
REASONABLE MAXIMUM EXPOSURE CONCENTRATIONS FOR CHEMICALS OF POTENTIAL CONCERN IN GROUNDWATER
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Chemicals of Potential Concern	Mean of Transformed Data	Standard Deviation of Data	H - Statistic Value (1)	Sample Size	95% UCL (2) (mg/l)	Maximum Concentration (mg/l)	RME Concentration (3) (mg/l)
<u>Background (4)</u>							
Aluminum	9.29	2.09	6.621	8	18202	58.3	58.3
Arsenic	1.61	0.46	2.22	10	0.008	0.008	0.008
Barium	4.40	0.92	2.902	9	0.32	0.173	0.173
Beryllium	0.91	0.34	2.089	10	0.003	0.005	0.003
Cadmium	1.22	0.63	2.532	10	0.007	0.013	0.007
Copper	4.11	1.08	3.639	9	0.417	0.272	0.272
Lead	1.68	0.93	3.103	9	0.023	0.017	0.017
Manganese	5.00	2.20	6.621	10	214	1.24	1.24
Nickel	3.09	0.49	2.22	9	0.036	0.076	0.036
Vanadium	3.71	1.30	4.207	10	0.592	0.156	0.156
<u>Onsite (5)</u>							
Benzene	1.29	0.68	2.532	10	0.008	0.005	0.005
Carbon Disulfide	1.56	0.16	1.881	10	0.005	0.003	0.003
Chlorobenzene	1.38	0.72	2.71	10	0.01	0.022	0.01
Chloromethane	1.63	0.06	1.802	10	0.005	0.006	0.005
1,4-Dichlorobenzene	1.29	0.74	2.71	9	0.01	0.007	0.007
1,2-Dichloroethane	1.38	0.53	2.271	11	0.007	0.002	0.002
1,1-Dichloroethene	1.46	0.49	2.141	11	0.007	0.001	0.001
Total 1,2-Dichloroethene	1.89	0.75	2.71	10	0.017	0.026	0.017
bis(2-Ethylhexyl)Phthalate	1.73	0.06	2.035	4	0.008	0.008	0.008
Hexachloroethane	1.59	0.07	1.802	9	0.005	0.004	0.004
Trichloroethene	1.52	0.29	1.977	10	0.006	0.005	0.005
Vinyl Chloride	2.07	0.80	2.71	10	0.022	0.05	0.022
Aluminum	10.12	0.62	3.662	4	109.9	55.7	55.7
Arsenic	1.74	0.37	2,089	9	0.008	0.009	0.008
Barium	5.08	1.37	4.207	10	2.837	0.61	0.61
Beryllium	1.06	1.33	4.207	10	0.045	0.002	0.002
Cadmium	1.32	0.76	2.71	8	0.011	0.014	0.011
Copper	2.93	1.11	3.639	9	0.146	0.152	0.146
Lead	1.56	1.32	4.207	9	0.080	0.056	0.056
Manganese	6.65	2.11	6.621	10	744	6.67	6.67
Nickel	3.16	0.43	2.22	9	0.036	0.08	0.036
Vanadium	3.08	0.77	2.71	10	0.059	0.111	0.059

TABLE 22
REASONABLE MAXIMUM EXPOSURE CONCENTRATIONS FOR CHEMICALS OF POTENTIAL CONCERN IN GROUNDWATER
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Chemicals of Potential Concern	Mean of Transformed Data	Standard Deviation of Data	H - Statistic Value (1)	Sample Size	95% UCL (2) (mg/l)	Maximum Concentration (mg/l)	RME Concentration (3) (mg/l)
Offsite Residential (6)							
Chloroform	-0.68	0.03	1.684	32	0.001	0.001	0.001
1,2-Dichloroethane	-0.65	0.24	1.761	32	0.001	0.002	0.001
1,1,2-Trichloroethane	-0.68	0.03	1.684	32	0.001	0.001	0.001
Arsenic	1.67	0.70	9.12	3	0.482	0.006	0.006

Notes:
One-half of the SQL or CRDL value is used as a proxy concentration for non-detects in the calculation of the 95% UCL.
Data qualified as A,J,K and L are used to calculate RME values.
(1) From Gilbert (1987).
(2) 95% upper confidence limit of the arithmetic mean.
(3) Reasonable Maximum Exposure (i.e., 95% UCL or maximum detected value if the UCL is greater).
(4) Based on chemical concentration in Monitoring Wells C-1, C-2, C-3, C-4, C-5, C-6, C-7, G-1, G-5, G-6, G-11, G-12, G-13, GR-16, GR-19, MD-2, MP-3, MP-6, MP-11, MP-14, M-15, M-16, M-17, MP-18, MP-19, NEIN, and Auction House.
(5) Based on chemical concentration in Monitoring Wells C-5, G-1, G-4, G-5, G-6, G-12, G-13, MP-14S, and MP-14D.
(6) Based on chemical concentrations in Monitoring Wells Bechtald, Berkel, Botch/Roberts, Breitegam, Buller, Cremer, and Faust.

TABLE 23

REASONABLE MAXIMUM EXPOSURE CONCENTRATIONS FOR CHEMICALS OF POTENTIAL CONCERN IN SURFACE SOIL

BERKS LANDFILL

BERKS COUNTY, PENNSYLVANIA

Chemicals of Potential Concern	Mean of Transformed Data	Standard Deviation of Data	H - Statistic Value (1)	Sample Size	95% UCL (2) (mg/kg)	Maximum Concentration (mg/kg)	RME Concentration (mg/kg)
Background (4)							
Beryllium	0.10	0.53	7.807	3	23.8	1.5	1.5
Onsite (5)							
Benzo(a)Pyrene	5.35	0.47	1.989	19	0.294	1.21	0.294
Arsenic	1.38	0.95	2.744	14	12.8	30.9	12.8
Beryllium	-0.02	0.47	1.989	19	1.37	2	1.37

Notes:

One-half of the SQL or CRDL value is used as a proxy concentration for non-detects in the calculation of the 95% UCL.

(1) From Gilbert (1987).

(2) 95% upper confidence limit of the arithmetic mean.

(3) Reasonable Maximum Exposure (i.e., 95% UCL or maximum detected value if the UCL is greater).

(4) Based on chemical concentration in surface soil samples S1-BG, S2-BG, and S3-BG.

(5) Based on chemical concentrations in onsite surface soil samples S1-EL, S1-WL, S2-EL, S2-WL, S3-EL, S3-WL, S4-EL, S4-WL, S5-EL, S5-WL, S6-EL, S6-WL, S7-EL, S7-WL, S8-EL S8-WL , S9-EL, S10-EL, and S11-EL.

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TABLE 24

REASONABLE MAXIMUM EXPOSURE CONCENTRATIONS FOR CHEMICALS OF POTENTIAL CONCERN IN SEDIMENT

BERKS LANDFILL

BERKS COUNTY, PENNSYLVANIA

Chemicals of Potential Concern	Mean of Transformed Data	Standard Deviation of Data	H - Statistic Value (1)	Sample Size	95% UCL (2) (mg/kg)	Maximum Concentration (mg/kg)	RME Concentration (mg/kg)
Background							
Arsenic	1.52	0.57	3.287	4	16	10.7	10.7
Beryllium	-0.02	0.34	2.089	4	1.58	1.5	1.5
Manganese	6.73	0.46	2.220	4	1676	1650	1650
Onsite							
Arsenic	0.86	0.54	2.368	10	4.15	4.4	4.15
Beryllium	-0.12	0.23	1.977	10	1.06	1.3	1.06
Manganese	6.82	0.18	1.881	10	1047	1309	1047

Notes:

One-half of the SQL or CRDL value is used as a proxy concentration for non-detects in the calculation of the 95% UCL.

(1) From Gilbert (1987).

(2) 95% upper confidence limit of the arithmetic mean.

(3) Reasonable Maximum Exposure (i.e., 95% UCL or maximum detected value if the UCL is greater).

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TABLE 25
REASONABLE MAXIMUM EXPOSURE CONCENTRATIONS FOR CHEMICALS OF POTENTIAL CONCERN IN AMBIENT AIR
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Chemicals of Potential Concern	Mean of Transformed Data	Standard Deviation of Data	H-Statistic Value (1)	Sample Size	95% UCL (2) (mg/m3)	Maximum Concentration (mg/m3)	RME (3) Concentration (mg/m3)
Benzene	-0.5957	0.6117	7.807	3	1.95E+01	0.92	0.92
Chlorobenzene	-0.8467	1.5721	19.6	3	4.28E+09	1.2	1.2
Chloroethane	0.0513	0.4281	5.22	3	5.60E+00	1.6	1.6
Dichlorodifluoromethane	0.0861	1.8953	26.14	3	1.07E+16	6.6	6.6
cis-1,2-Dichloroethene	-1.1531	2.2881	32.69	3	4.04E+23	4.3	4.3
Ethylbenzene	2.8899	2.2584	32.69	3	1.08E+25	140	140
Hydrogen Sulfide	0.5998	2.4326	32.69	3	9.25E+25	18.04	18.04
Toluene	1.418	3.7605	45.77	3	3.49E+56	68	68
Trichloroethene	-1.1952	1.7162	22.87	3	1.49E+12	2.1	2.1
1,2,4-Trimethylbenzene	1.377	1.8758	22.87	3	3.44E+14	21	21
1,3,5-Trimethylbenzene	0.8414	1.7035	22.87	3	9.11E+12	12	12
Vinyl Chloride	0.4198	2.6224	32.69	3	1.00E+28	15	15
Total Xylenes	4.1343	1.4993	19.6	3	2.03E+11	330	330

Notes:
(1) From Gilbert (1987).
(2) 95% upper confidence limit of the arithmetic mean.
(3) Reasonable Maximum Exposure (i.e., 95% UCL or maximum detected value if the UCL is greater).

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TABLE 26
POTENTIAL EXPOSURE ROUTES AND HUMAN RECEPTORS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Exposure Medium/ Exposure Route	Potentially Exposed Population			
	Off-Site Resident	On-Site Trespasser[1]	Maintenance Worker[2]	On-Site Resident[3]
Groundwater				
Ingestion	X[4]			X[5]
Dermal Contact	X[4]			X[5]
Inhalation of Vapors	X[4]			X[5]
Soil				
Incidental Ingestion		X	X	
Dermal Contact		X	X	
Sediment				
Dermal Contact		X		
Air				
Inhalation of Volatiles	X[6]	X[6]	X[6]	X[7]

1 A trespasser is assumed to be exposed to chemicals in surface soil and sediment under both current and future use scenarios.

2 An on-site maintenance worker is assumed to contact surficial soils and air while performing maintenance activities at the Site under the future exposure scenario.

3 While an on-site residence has been considered in the risk assessment, it should be pointed out that the only downgradient on-site residential property (Nein residence) was destroyed in a fire in November, 1992; is an undesirable piece of property; has no public water supply or acceptable drinking water well (only a shallow hand-dug well exists); and, therefore, might not be restored to residential use. It should also be noted that while the Cass residence is located on-site, it is hydrogeologically upgradient of the landfills.

4 An off-site resident is assumed to be exposed to groundwater under both current and future exposure scenarios.

5 An on-site resident is assumed to be exposed to groundwater under future exposure scenarios only.

6 An off-site resident and an on-site trespasser are assumed to be exposed to vapor-phase chemicals in landfill gas passive vents under current and future exposure conditions. An on-site maintenance worker is assumed to be exposed in the future only.

7 An on-site resident is assumed to have the same exposure as an off-site resident exposed to vapor-phase chemicals in passive gas vents under future exposure scenarios only.

TABLE 27
EXPOSURE FACTORS FOR INGESTION OF GROUNDWATER
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Equation: *Intake (mg/kg-day)* = $\frac{CW \times IR \times EF \times ED}{BW \times AT}$ from USEPA (1989a)

Parameter		Assumed Factors for Receptors	
		Adult	Child
CW =	Chemical Concentration in Water (mg/L)	RME Concentration from Table 22	
IR =	Ingestion Rate (L/day) [1]	2	1
EF =	Exposure Frequency (days/yr) [1]	350	350
ED =	Exposure Duration (yrs) [2]	24	6
BW =	Body Weight (kg) [1]	70	15
AT =	Averaging Time (days) [3]		
	Noncarcinogens	8,760	2,190
	Carcinogens	25,550	25,550

1 USEPA (1989c and 1991a).
2 30 years is the national upper-bound time (90th percentile) at one residence (USEPA, 1989c). The 30-year exposure duration is divided between the child (6 years) and adult (24 years).
3 USEPA (1989a).

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TABLE 28
EXPOSURE FACTORS FOR DERMAL CONTACT WITH GROUNDWATER (SHOWERING/BATHING)
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Equation:

$$\text{Absorbed Dose (mg/kg-day)} = \frac{CW \times SA \times PC \times ET \times EF \times ED \times \frac{1\ L}{1000\ cm^3}}{BW \times AT}$$

from USEPA (1989a)

Parameter	Assumed Factors for Off-site Resident	
CW = Chemical Concentration in Water (mg/L)	RME Concentration from Table 22	
	Adult (Showering)	Child (Bathing)
SA = Skin Surface Area Exposed (cm^2)	18,150 [1]	7,280 [1]
PC = Dermal Permeability Coefficient (cm/hr)	Chemical-specific coefficients [2]	
ET = Exposure Time (hrs/day) [3]	0.2	0.2
EF = Exposure Frequency (days/yr) [4]	350	350
ED = Exposure Duration (yrs) [5]	24	6
BW = Body Weight (kg) [4]	70	15
AT = Averaging Time (days) [6]		
Noncarcinogens	10,950	2,190
Carcinogens	25,550	25,550

1 Calculated value for average total body surface areas for adults and children (USEPA, 1989c).
2 USEPA (1992a).
3 Exposure time of 0.2 hours/day or 12 minutes/day is based on 90th percentile value for time spent showering (USEPA, 1989c).
4 USEPA (1991a).
5 30 years is the national upper-bound time (90th percentile) at one residence (USEPA, 1989c). The 30-year exposure duration is divided between the child (6 years) and adult (24 years).
6 USEPA (1989a).

TABLE 29
EXPOSURE FACTORS FOR INHALATION OF AIRBORNE CHEMICALS IN GROUNDWATER (SHOWERING)
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Equation: *Intake (mg/kg-day)* = $\frac{SD \times EF \times ED}{AT}$ adapted from USEPA (1989a)

Parameter		Assumed Factors for Off-site Resident (Adult)
SD =	Shower Dose (mg/kg per shower) derived from model.	From Foster and Chrostowski Shower Model (See Appendix A)
IR =	Inhalation Rate (L/min) [1]	10
EF =	Exposure Frequency (days/yr) [2]	350
ED =	Exposure Duration (yrs) [3]	30
AT =	Averaging Time (days) [4]	
	Noncarcinogens	10,950
	Carcinogens	25,550

1 USEPA (1989c).
2 USEPA (1991a).
3 30 years is the national upper-bound time (90th percentile) at one residence (USEPA, 1989c).
4 USEPA (1989a).

TABLE 30
EXPOSURE FACTORS FOR INGESTION OF SOIL
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Equation:

$$\text{Intake (mg/kg-day)} = \frac{CS \times IR \times FI \times BF \times EF \times ED \times \frac{1\ kg}{10^6\ mg}}{BW \times AT}$$

from USEPA (1989a)

Parameter		Assumed Factors	
		On-site Trespasser	On-site Worker
CS =	Chemical Concentration in Soil (mg/kg)	RME Concentration from Table 23	
IR =	Ingestion Rate (mg/day)	100 [1]	50 [1]
FI =	Fraction Ingested from Affected Source (unitless)	1	1
BF =	Bioavailability Factor (unitless)	1	1
EF =	Exposure Frequency (days/yr)	50 [2]	24
ED =	Exposure Duration (yrs)	9 [3]	25 [1]
BW =	Body Weight (kg)	55 [2]	70 [1]
AT =	Averaging Time (days) [4]		
	Noncarcinogens	3,285	9,125
	Carcinogens	25,550	25,550

1 USEPA (1991a).
2 USEPA Region III directive to Golder during a telephone conference on May 3, 1994.
3 Represents exposure duration of 9 years for an older child (see Section 8.1.3 of text).
4 USEPA (1989a).

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TABLE 31
EXPOSURE FACTORS FOR INHALATION OF AIRBORNE CHEMICALS FROM PASSIVE VENTS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Equation: *Intake (mg/kg-day)* = $\frac{CA \times IR \times ET \times EF \times ED}{BW \times AT}$ from USEPA (1989a)

Parameter		Assumed Factors		
		Off-Site Resident	On-Site Trespasser	On-Site Worker
		Adult		
CA =	Chemical Concentration in Air (mg/m^3)	RME Concentration from Table D-1 (See Appendix D)		
IR =	Inhalation Rate (m^3/hr) [1]	0.83	0.83	0.83
ET =	Exposure Time (hrs/day)	0.44 [1]	2.4	8 [2]
EF =	Exposure Frequency (days/yr)	350 [1]	50	24 [1]
ED =	Exposure Duration (yrs)	30 [3]	9 [4]	25 [1]
BW =	Body Weight (kg)	70 [1]	55 [2]	70 [1]
AT =	Averaging Time (days) [5]			
	Noncarcinogens	10,950	3,285	9,125
	Carcinogens	25,550	25,550	25,550

1 USEPA (1989c).
2 USEPA Region III directive to Golder during a telephone conference on May 3, 1994.
3 30 years is the national upper-bound time (90th percentile) at one residence (USEPA, 1991a).
4 Represents exposure duration of 9 years for an older child (see Section 8.1.3 of text).
5 USEPA (1989a).

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TABLE 32
ESTIMATED CANCER RISKS AND HAZARD INDICES(1)
BACKGROUND CHEMICAL CONCENTRATIONS
CURRENT AND FUTURE USE SCENARIOS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Exposure Medium	Exposure Route	6-yr Child Receptor		24-yr Adult Receptor		Lifetime Receptor (6-yr and 24-yr)	
		Cancer Risk Estimate	Hazard Index Estimate	Cancer Risk Estimate	Hazard Index Estimate	Cancer Risk Estimate	Hazard Index Estimate
Groundwater (2)	Ingestion	1E-04	24	2E-04	11	3E-04	14 (5)
	Dermal Contact (Bathing)	2E-06	0.1	NA	NA	2E-06	0.1
	Inhalation of Volatiles (Showering)	NA	NA	NA	NA	NA	NA
Surface Soil (3,4)	Incidental Ingestion	2E-07	0.00007	NA	NA	2E-07	0.00007
	Total Cancer Risk and HI	1E-04	24	2E-04	11	3E-04	14 (5)

Notes:

(1) Chemical-specific cancer risks and hazard quotients are presented in Appendix E.
(2) Only detected inorganic chemicals in background groundwater are assessed.
(3) Beryllium detected in background soil is assessed for potential incidental ingestion exposure by a child trespasser (see Section 4.2.2 of text for discussion).
(4) Beryllium is not recommended for quantitative risk assessment via dermal exposure (USEPA, 1992a).
(5) The hazard index estimate represents a time weighted average of child and adult resident hazard index estimates.
NA = Not Applicable

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TABLE 33
ESTIMATED CANCER RISKS AND HAZARD INDICES(1)
OFF-SITE RESIDENTIAL EXPOSURE
CURRENT AND FUTURE USE SCENARIOS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Exposure Medium	Exposure Route	6-yr Child Resident		24-yr Adult Resident		Lifetime Resident (6-yr and 24-yr)	
		Cancer Risk Estimate	Hazard Index Estimate	Cancer Risk Estimate	Hazard Index Estimate	Cancer Risk Estimate	Hazard Index Estimate
Groundwater	Ingestion	6E-05	1	1E-04	0.6	2E-04	0.7 (3)
	Dermal Contact (Bathing)	3E-08	8E-04	NA	NA	3E-08	8E-04
	Inhalation of Volatiles (Showering)	NA	NA	3E-06	0.01	3E-06	0.01
Air	Inhalation of Volatiles (2)	NA	NA	2E-05	0.7	2E-05	0.7
	Total Cancer Risk and HI	6E-05	1	1E-04	0.6	2E-04	(4)

Notes:

(1) Chemical-specific cancer risk and hazard quotients are presented in Appendix E.
(2) Exposure is assumed for an adult resident for a 30-year duration (USEPA, 1989c).
(3) The hazard index estimate represents a time weighted average of child resident and adult resident hazard index estimates.
(4) The total hazard index is 1.4, however, groundwater ingestion hazard is primarily due to arsenic while volatile inha'ation hazard is primarily attributed to hydrogen sulfide. These compounds do not share the same toxic endpoints or target organs. Therefore, it is not appropriate to assume dose additivity as recommended in USEPA, 1989a.
NA = Not Applicable

TABLE 34
ESTIMATED CANCER RISKS AND HAZARD INDICES(1)
ON-SITE TRESPASSER EXPOSURE
CURRENT AND FUTURE USE SCENARIOS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Exposure Medium	Exposure Route	Trespasser Receptor(2)	
		Cancer Risk Estimate	Hazard Index Estimate
Surface Soil(3)	Incidental Ingestion	1E-06	0.01
Air	Inhalation of Volatiles	3E-08	0.004
	Total Cancer Risk and HI	1E-06	0.01

Notes:

(1) Chemical-specific cancer risks and hazard quotients are presented in Appendix E.
(2) COPCs were not selected for surface water, leachate lagoon water, or leachate seep water; therefore, potential exposure to these media are not included in the assessment of potential risks (see Section 4.2 of text for discussion).
(3) None of the selected COPCs in soil (and sediment) media at the Site include compounds that are recommended by the USEPA (1992a) for quantitative assessment via dermal exposure (see Section 8.3.2 of text for discussion).

TABLE 35
ESTIMATED CANCER RISKS AND HAZARD INDICES(1)
ON-SITE WORKER EXPOSURE
FUTURE USE SCENARIO
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Exposure Medium	Exposure Route	Worker Receptor	
		Cancer Risk Estimate	Hazard Index Estimate
Surface Soil(2)	Incidental Ingestion	5E-07	0.002
Air	Inhalation of Volatiles	1E-07	0.005
	Total Cancer Risk and HI	6E-07	0.007

Notes:

(1) Chemical-specific cancer risks and hazard quotients are presented in Appendix E.

(2) None of the selected COPCs in soil (and sediment) media at the Site include compounds that are recommended by the USEPA (1992a) for assessment via dermal exposure (see Section 8.3.2 of text for discussion).

TABLE 36
ESTIMATED CANCER RISKS AND HAZARD INDICES(1)
ON-SITE RESIDENTIAL EXPOSURE
FUTURE USE SCENARIO
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Exposure Medium	Exposure Route	6-yr Child Resident		24-yr Adult Resident		Lifetime Resident (6-yr and 24-yr)	
		Cancer Risk Estimate	Hazard Index Estimate	Cancer Risk Estimate	Hazard Index Estimate	Cancer Risk Estimate	Hazard Index Estimate
Groundwater	Ingestion	4E-04	94	6E-04	40	1E-03	50 (3)
	Dermal Contact (Bathing)	4E-06	0.5	NA	NA	4E-06	0.5
	Inhalation of Volatiles (Showering)	NA	NA	2E-04	0.3	2E-04	0.3
Air	Inhalation of Volatiles(2)	NA	NA	0.0000001	0.004	0.0000001	0.004
	Total Cancer Risk and HI	4E-04	95	8E-04	40	1E-03	50 (3)

Notes:

(1) Chemical-specific cancer risk and hazard quotients are presented in Appendix E.
(2) Exposure is assumed for an adult resident for a 30-year duration (USEPA, 1989c).
(3) The hazard index estimate represents a time weighted average of child and adult resident hazard index estimates.
NA = Not Applicable

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TABLE 37
MODELED BLOOD LEAD LEVELS BY AGE GROUP
ON-SITE GROUNDWATER RESIDENTIAL EXPOSURE
FUTURE USE SCENARIO
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Groundwater Lead Concentration = 15.3 ug/L	Percentile Below 10 ug/dL Blood Lead Concentration	
Soil/Dust Lead Concentration = 14.6 ug/g	Year 0-7	Year 1-2
	99.83	99.65

Integrated Exposure/Uptake/Biokinetic Model,
Version 0.99d (USEPA, 1994d).

Assumptions:

- Air concentration: 0.10 ug Pb/m^3 (default value)
- Diet data: (default values)
- Paint intake: 0.0 ug Pb/day (default value)
- Maternal contribution: Infant model (default value)
- Water concentration: Average concentration from selected on-site monitoring wells (C-5, G-1, G-4, G-5, G-6, G-12, G-13, MP-14S, and MP-14D).
- Soil/Dust concentration: On-site average

TABLE 38

UPTAKE AND TOXICITY FACTORS FOR EVALUATING CHEMICAL CONSTITUENT INTAKE BY THE MEADOW VOLE BERKS LANDFILL BERKS COUNTY, PENNSYLVANIA

Constituent	Soil/Plant Uptake Factor (1) (kg soil/kg plant)	Toxicity Factor LD_{50} (2)		Toxicity Factor NOAEL (3)	
		Lab Mouse or Rat (mg/kg)	Vole (mg/kg)	Lab Mouse or Rat (mg/kg)	Vole (mg/kg)
Inorganics					
Aluminum	0.001	260	229	10	8.8
Antimony	0.03	7,000	13,973	0.95	0.84
Arsenic	0.006	145	128	0.095	0.08
Barium	0.02	ND (4)	NE (5)	0.51	1.0
Beryllium	0.002	86	172	0.054	0.11
Cadmium	0.2	890	783	0.19	0.17
Calcium	0.4	ND	NE	ND	NE
Chromium	0.005	27.5	55	2.4	4.8
Cobalt	0.007	6171	12,319	ND	NE
Copper	0.3	3.5	3	0.17	0.15
Iron	0.004	30,000	59,886	ND	NE
Lead	0.05	438	874	0.48	0.42
Magnesium	1.0	ND	NE	ND	NE
Manganese	0.3	9,000	17,966	ND	NE
Mercury	0.9	ND	NE	ND	NE
Nickel	0.06	ND	NE	5	10
Potassium	1.0	700	616	ND	NE
Selenium	0.03	6,700	13,375	0.057	0.05
Silver	0.4	100	88	0.04	0.08
Sodium	0.08	4,000	3,521	ND	NE
Vanadium	0.006	23	46	0.95	0.84
Zinc	1.5	ND	NE	9.7	19
Organics					
Acenaphthene	0.2	600	1,198	17.5	15.4
Acetone	NE	3,000	2,640	10	20
Anthracene	0.1	430	378	100	88
Aroclor-1248	0.01	11,000	21,958	0.22	0.19
Benzo(a)Anthracene	0.02	200	399	ND	NE
Benzo(a)Pyrene	0.01	50	100	1	2
Benzo(b)Fluoranthene	0.01	ND	NE	ND	NE

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TABLE 38

UPTAKE AND TOXICITY FACTORS FOR EVALUATING CHEMICAL CONSTITUENT INTAKE BY THE MEADOW VOLE BERKS LANDFILL BERKS COUNTY, PENNSYLVANIA

Constituent	Soil/Plant Uptake Factor (1) (kg soil/kg plant)	Toxicity Factor LD_{50} (2)		Toxicity Factor NOAEL (3)	
		Lab Mouse or Rat (mg/kg)	Vole (mg/kg)	Lab Mouse or Rat (mg/kg)	Vole (mg/kg)
Organics, cont'd.					
Benzo(g,h,i)Perylene	0.01	ND	NE	ND	NE
Benzo(k)Fluoranthene	0.01	ND	NE	ND	NE
2-Butanone	27.4	4,050	3,565	ND	NE
Butylbenzylphthalate	0.07	4,170	3,670	280	559
Carbazole	0.5	5,000	9,981	ND	NE
Chlorobenzene	0.9	2,300	2,024	60	53
Chloroform	2.8	36	32	9	18
Chrysene	0.02	320	282	ND	NE
Di-n-Octyl Phthalate	NE	6,513	5,732	12.5	11
Dibenz(a,h)Anthracene	0.0	ND	NE	ND	NE
Dibenzofuran	0.2	ND	NE	ND	NE
1,4-Dichlorobenzene	0.3	2,950	2,596	ND	NE
Ethylbenzene	0.6	3,500	6,987	9.71	19.4
Fluoranthene	0.06	2,000	3,992	12.5	11
Fluorene	0.1	2,000	1,760	ND	NE
Indeno(1,2,3-cd)Pyrene	0.01	ND	NE	ND	NE
2-Methylnaphthalene	NE	1,630	3,254	ND	NE
4-Methyl-2-Pentanone	NE	2,671	2,351	5	10
Naphthalene	0.7	533	469	ND	NE
Pentachlorophenol	0.05	117	103	3	6
Phenanthrene	0.1	700	616	ND	NE
Phenol	5.6	270	238	60	120
Pyrene	0.06	800	704	7.5	6.6
Toluene	1.0	636	1,270	22.3	44.5
Total Xylenes	0.5	4,300	8,584	250	499

1) Baes et al. (1984); Travis and Arms (1988).
2) LD_{50} = median lethal dose. See ERA text (section 12.2.1.3)
3) NOAEL = No adverse effects level. See ERA text (section 12.2.1.3)
4) ND = Not determined
5) NE = Not evaluated

TABLE 39

POTENTIAL CHEMICAL CONSTITUENT INTAKES FROM SOIL
AND ENVIRONMENTAL HAZARD QUOTIENTS (EHQ) FOR THE MEADOW VOLE
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituent	RME	CDv	CDs	CD Total	EHQ	
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	LD_{50}	NOAEL
ONSITE SOIL						
Inorganics						
Aluminum	25,114	0.62	71.9	72.5	0.3	8
Antimony	2.2	<0.005	0.01	0.01	<0.05	<0.05
Arsenic	12.8	<0.005	0.04	0.04	<0.05	0.5
Barium	159	0.09	0.46	0.55	NE	0.5
Beryllium	1.4	<0.005	<0.005	<0.005	<0.05	<0.05
Cadmium	4.5	0.03	0.01	0.04	<0.05	0.2
Calcium	9,773	131	28	159	NE	NE
Chromium	241	0.04	0.69	0.73	<0.05	0.2
Cobalt	22.4	0.01	0.06	0.07	<0.05	NE
Copper	69.5	0.66	0.20	0.86	0.3	6
Iron	51,421	7.85	147	155	<0.05	NE
Lead	22.7	0.04	0.07	0.10	<0.05	0.3
Magnesium	16,096	614	46.1	660	NE	NE
Manganese	1,013	9.66	2.90	12.6	<0.05	NE
Mercury	0.1	<0.005	<0.005	<0.005	NE	NE
Nickel	132	0.30	0.38	0.68	NE	0.1
Potassium	1,646	62.8	4.71	67.6	0.1	NE
Selenium	4.0	<0.005	0.01	0.02	<0.05	0.3
Silver	0.7	0.01	<0.005	0.01	<0.05	0.2
Sodium	2,310	6.61	6.61	13.2	<0.05	NE
Vanadium	80.6	0.02	0.23	0.25	<0.05	0.3
Zinc	156	8.90	0.45	9.35	NE	0.5
Organics						
Acenaphthene	239	<0.005	<0.005	<0.005	<0.05	<0.05
Acetone	110	NE	<0.005	<0.005	<0.05	<0.05
Anthracene	271	<0.005	<0.005	<0.005	<0.05	<0.05
Aroclor-1248	114	<0.005	<0.005	<0.005	<0.05	<0.05
Benzo(a)Anthracene	330	<0.005	<0.005	<0.005	<0.05	NE

TABLE 39

POTENTIAL CHEMICAL CONSTITUENT INTAKES FROM SOIL AND ENVIRONMENTAL HAZARD QUOTIENTS (EHQ) FOR THE MEADOW VOLE BERKS LANDFILL BERKS COUNTY, PENNSYLVANIA

Constituent	RME	CDv	CDs	CD Total	EHQ	
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	LD_{50}	NOAEL
Organics, cont'd.						
Benzo(a)Pyrene	295	<0.005	<0.005	<0.005	<0.05	<0.05
Benzo(b)Fluoranthene	150	<0.005	<0.005	<0.005	NE	NE
Benzo(g,h,i)Perylene	250	<0.005	<0.005	<0.005	NE	NE
Benzo(k)Fluoranthene	68.0	<0.005	<0.005	<0.005	NE	NE
2-Butanone	8.0	0.01	<0.005	0.01	<0.05	NE
Butylbenzylphthalate	63.0	<0.005	<0.005	<0.005	<0.05	<0.05
Carbazole	225	<0.005	<0.005	0.01	<0.05	NE
Chlorobenzene	2.0	<0.005	<0.005	<0.005	<0.05	<0.05
Chloroform	6.0	<0.005	<0.005	<0.005	<0.05	<0.05
Chrysene	308	<0.005	<0.005	<0.005	<0.05	NE
Di-n-Octyl Phthalate	54.0	NE	<0.005	<0.005	<0.05	<0.05
Dibenz(a,h)Anthracene	220	<0.005	<0.005	<0.005	NE	NE
Dibenzofuran	233	<0.005	<0.005	<0.005	NE	NE
1,4-Dichlorobenzene	120	<0.005	<0.005	<0.005	<0.05	NE
Ethylbenzene	8.7	<0.005	<0.005	<0.005	<0.05	<0.05
Fluoranthene	456	<0.005	<0.005	<0.005	<0.05	<0.05
Fluorene	256	<0.005	<0.005	<0.005	<0.05	NE
Indeno(1,2,3-cd)Pyrene	246	<0.005	<0.005	<0.005	NE	NE
4-Methyl-2-Pentanone	4.0	NE	<0.005	<0.005	<0.05	NE
2-Methylnaphthalene	120	NE	<0.005	<0.005	<0.05	NE
Naphthalene	227	0.01	<0.005	0.01	<0.05	NE
Pentachlorophenol	110	<0.005	<0.005	<0.005	<0.05	<0.05
Phenanthrene	398	<0.005	<0.005	<0.005	<0.05	NE
Phenol	120	0.03	<0.005	0.03	<0.05	<0.05
Pyrene	422	<0.005	<0.005	<0.005	<0.05	<0.05
Toluene	15.5	<0.005	<0.005	<0.005	<0.05	<0.05
Total Xylenes	12.5	<0.005	<0.005	<0.005	<0.05	<0.05

TABLE 39

POTENTIAL CHEMICAL CONSTITUENT INTAKES FROM SOIL AND ENVIRONMENTAL HAZARD QUOTIENTS (EHQ) FOR THE MEADOW VOLE
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituent	RME	CDv	CDs	CD Total	EHQ	
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	LD_{50}	NOAEL
BACKGROUND SOILS						
Inorganics						
Aluminum	26600	0.66	76.2	76.8	0.3	9
Arsenic	2.3	<0.005	0.01	0.01	<0.05	0.1
Barium	151	0.09	0.43	0.52	NE	0.5
Beryllium	1.5	<0.005	<0.005	<0.005	<0.05	0.04
Calcium	5740	76.7	16.4	93.1	NE	NE
Chromium	91.8	0.02	0.26	0.28	0.01	0.06
Cobalt	34.8	0.01	0.10	0.11	<0.05	NE
Copper	408	3.89	1.17	5.06	1.6	34
Iron	65900	10.1	189	199	<0.05	NE
Lead	31.2	0.05	0.09	0.14	<0.05	0.3
Magnesium	3550	136	10.2	146	NE	NE
Manganese	675	6.44	1.93	8.37	<0.05	NE
Nickel	37.3	0.09	0.11	0.19	NE	0.02
Potassium	3130	120	8.96	128	0.2	NE
Vanadium	152	0.03	0.44	0.47	0.01	0.6
Zinc	151	8.65	0.43	9.08	NE	0.5
Organics						
Butylbenzylphthalate	44.0	<0.005	<0.005	<0.005	<0.05	<0.05
Chrysene	47.0	<0.005	<0.005	<0.005	<0.05	NE
Fluoranthene	68.0	<0.005	<0.005	<0.005	<0.05	<0.05
Pyrene	41.0	<0.005	<0.005	<0.005	<0.05	<0.05

NOTES:

- RME = Reasonable Maximum Exposure Concentration
- CDv = Chemical dose from vegetation ingestion
- CDs = Chemical dose from soil ingestion
- CD = Chemical dose (CD Total is the sum of CDv and CDs)
- NE = Not evaluated

TABLE 40

RISK CHARACTERIZATION FOR CHEMICAL CONSTITUENTS FOUND IN STREAM SEDIMENT SAMPLES: RMEs, SEDIMENT CRITERIA, AND ENVIRONMENTAL HAZARD QUOTIENTS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituent	RME (1)	NOAA Sediment Criteria (2)		EHQ (3)	
		ER-Median (ppm)	ER-Low (ppm)	ER-M	ER-L
ONSITE SEDIMENT					
Inorganics	(mg/kg)				
Aluminum	13,317	NA (4)	NA	NA	NA
Arsenic	4.1	85	33	0.1	0.1
Barium	94.0	NA	NA	NA	NA
Beryllium	1.1	NA	NA	NA	NA
Cadmium	4.1	9	5	0.5	0.8
Calcium	8,841	NA	NA	NA	NA
Chromium	35	145	80	0.2	0.4
Cobalt	20.1	NA	NA	NA	NA
Copper	61.9	390	70	0.2	0.9
Iron	32,377	NA	NA	NA	NA
Lead	15.9	110	35	0.2	0.5
Magnesium	5,573	NA	NA	NA	NA
Manganese	1,046	NA	NA	NA	NA
Mercury	0.1	1.3	0.15	0.1	0.7
Nickel	20.6	50	30	0.4	0.7
Potassium	922	NA	NA	NA	NA
Vanadium	119	NA	NA	NA	NA
Zinc	87.2	270	120	0.3	0.7
Organics	(Tg/kg)				
Benzo(a)Anthracene	100	1600	230	0.1	0.4
Benzo(b)Fluoranthene	67	NA	NA	NA	NA
Chrysene	89	2800	400	0.0	0.2
Fluoranthene	180	3600	600	0.1	0.3
Phenanthrene	130	1380	225	0.1	0.6
Pyrene	110	2200	350	0.1	0.3
EHI (5)				2	7

TABLE 40

RISK CHARACTERIZATION FOR CHEMICAL CONSTITUENTS FOUND IN STREAM SEDIMENT SAMPLES: RMEs, SEDIMENT CRITERIA, AND ENVIRONMENTAL HAZARD QUOTIENTS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituent	RME (1)	NOAA Sediment Criteria (2)		EHQ (3)	
		ER-Median (ppm)	ER-Low (ppm)	ER-M	ER-L
BACKGROUND SEDIMENT					
Inorganics	(mg/kg)				
Aluminum	24,000	NA (4)	NA	NA	NA
Arsenic	10.7	85	33	0.1	0.3
Barium	102	NA	NA	NA	NA
Beryllium	1.5	NA	NA	NA	NA
Calcium	7,040	NA	NA	NA	NA
Chromium	23.6	145	80	0.2	0.3
Cobalt	21.3	NA	NA	NA	NA
Copper	69.6	390	70	0.2	1.0
Iron	36,000	NA	NA	NA	NA
Lead	31.4	110	35	0.3	0.9
Magnesium	4,250	NA	NA	NA	NA
Manganese	1,650	NA	NA	NA	NA
Nickel	17.5	50	30	0.4	0.6
Potassium	1,430	NA	NA	NA	NA
Sodium	904	NA	NA	NA	NA
Vanadium	134	NA	NA	NA	NA
Zinc	90.5	270	120	0.3	0.8
Organics	(Tg/kg)				
Benzo(a)Anthracene	170	1,600	230	0.1	0.7
Benzo(a)Pyrene	110	2,500	400	0.0	0.3
Benzo(b)Fluoranthene	61	NA	NA	NA	NA
Benzo(k)Fluoranthene	79	NA	NA	NA	NA
Chrysene	130	2,800	400	0.1	0.3
Fluoranthene	260	3,600	600	0.1	0.4
Indeno(1,2,3-cd)Pyrene	88	NA	NA	NA	NA
Phenanthrene	87	1,380	2250	0.1	0.4
Pyrene	190	2,200	350	0.1	0.5
EHI (5)				2	7

1) RME = Reasonable Maximum Exposure
2) Long and Morgan (1991)
3) EHQ = Environmental Hazard Quotient
4) NA = Not Available
5) EHI = Environmental Hazard Index

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TABLE 41

RISK CHARACTERIZATION FOR CHEMICAL CONSTITUENTS FOUND IN SURFACE WATER SAMPLES: RMEs, WATER QUALITY CRITERIA, AND ENVIRONMENTAL HAZARD QUOTIENTS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituent	RME (1) (Tg/L)	Chronic Aquatic Life Water Quality Criteria		EHQ (4)	
		(federal) (2) (1g/L)	(state) (3) (1g/L)	federal	state
BACKGROUND SURFACE WATER					
Inorganics					
Barium	23.5	NA (5)	4,100	NA	<0.05
Calcium	35,020	NA	NA	NA	NA
Copper	4.2	16.5	16.5	0.3	0.3
Iron	461	1,000	NA	0.5	NA
Magnesium	12,359	NA	NA	NA	NA
Manganese	67.3	NA	NA	NA	NA
Potassium	1,800	NA	NA	NA	NA
Selenium	3.1	5	5	0.6	0.6
Sodium	3,727	NA	NA	NA	NA
EHI				1.4	0.9
ONSITE SURFACE WATER					
Inorganics					
Aluminum	238	NA	NA	NA	NA
Barium	35.4	NA	4,100	NA	<0.05
Calcium	47,090	NA	NA	NA	NA
Cyanide	23.4	5.2	5	4.5	4.7
Iron	675	1,000	NA	0.7	NA
Magnesium	14,763	NA	NA	NA	NA
Manganese	276	NA	NA	NA	NA
Potassium	3,418	NA	NA	NA	NA
Sodium	10,100	NA	NA	NA	NA
Vanadium	4.8	NA	103	NA	0.1
EHI (6)				5	5

TABLE 41

RISK CHARACTERIZATION FOR CHEMICAL CONSTITUENTS FOUND IN SURFACE WATER SAMPLES: RMEs, WATER QUALITY CRITERIA, AND ENVIRONMENTAL HAZARD QUOTIENTS BERKS LANDFILL BERKS COUNTY, PENNSYLVANIA

1) RME = Reasonable Maximum Exposure
2) Quality Criteria for Water Update #2 (USEPA, 1987).
3) Pennsylvania Code, Title 25, Chapter 16, Subchapter A, Appendix A Table 1: Guidelines for Development of Criteria for Toxic Substances and Water Quality Criteria for Toxic Substances.
4) EHQ = Environmental Hazard Quotient
5) NA = Not Available
6) EHI = Environmental Hazard Index

Notes:

Federal Quality Criteria for Water and Pennsylvania Surface Water Criteria for Toxic Substances include hardness-dependent standards for protection of aquatic life as follows:

cadmium = e((0.7852*(ln(ppm hardness)))-3.490)
chromium = 11+e((0.819*(ln(ppm hardness)))+1.561)
copper = e((0.8545*(ln(ppm hardness)))-1.465)
lead = e((1.266*(ln(ppm hardness)))-4.661
nickel = e((0.846*(ln(ppm hardness)))_1.1645)
zinc = e((0.8473*(ln(ppm hardness)))+0.76140)

An average value of 148 ppm hardness was used to calculate surface water standards for cadmium, chromium, copper, lead, nickel, and zinc as shown in this table.

TABLE 42

RISK CHARACTERIZATION FOR CHEMICAL CONSTITUENTS FOUND IN LEACHATE LAGOON AND LEACHATE SEEP SAMPLES: RMEs, WATER QUALITY CRITERIA, AND ENVIRONMENAL HAZARD QUOTIENTS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituent	RME (1) (1g/L)	Chronic Aquatic Life Water Qaulity Criteria		EHQ (4)	
		(federal)(2) (1g/L)	(state) (3) (1g/L)	(federal)	(state)
LEACHATE LAGOON					
Inorganics					
Barium	623	NA (5)	4,100	NA	0.2
Calcium	173,000	NA	NA	NA	NA
Chromium	13.8	893	904	0.0	<0.05
Cobalt	11.8	NA	19	NA	0.6
Iron	35,400	1,000	NA	35.4	NA
Magnesium	86,500	NA	NA	NA	NA
Manganese	5,830	NA	NA	NA	NA
Nickel	31.1	714	714	0.0	<0.05
Potassium	38,500	NA	NA	NA	NA
Sodium	275,000	NA	NA	NA	NA
Organics	(1g/L)				
Acetone	100	NA	86,000	NA	<0.05
Benzene	21	NA	128	NA	0.2
2-Butanone	190	NA	NA	NA	NA
Chlorobenzene (6)	10	50	236	0.2	<0.05
1,2-Dichlorobenzene	3	763	164	0.0	<0.05
1,4-Dichlorobenzene	7.5	763	146	0.0	0.1
1,1-Dichloroethane	4	NA	NA	NA	NA
1,1-Dichloroethene	12	NA	1,492	NA	<0.05
1,2-Dichloroethene	75	NA	NA	NA	NA
Diethylphthalate (6)	1	3	800	0.3	<0.05
2,4-Dimethylphenol	1	NA	132	NA	<0.05
Ethylbenzene	79	NA	580	NA	0.1
Isophorone	1.5	NA	2,080	NA	<0.05
4-Methyl-2-Pentanone	28	NA	NA	NA	NA
2-Methylphenol	2	NA	NA	NA	NA
4-Methylphenol	170	NA	NA	NA	NA
Naphthalene (6)	3	620	43	0.0	0.1

TABLE 42

RISK CHARACTERIZATION FOR CHEMICAL CONSTITUENTS FOUND IN LEACHATE LAGOON AND LEACHATE SEEP SAMPLES: RMEs, WATER QUALITY CRITERIA, AND ENVIRONMENTAL HAZARD QUOTIENTS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituent	RME (1) (1g/L)	Chronic Aquatic Life Water Qaulity Criteria		EHQ (4)	
		(federal)(2) (1g/L)	(state) (3) (1g/L)	(federal)	(state)
Organics, cont'd.					
Phenol (6)	30	2,560	20	0.0	1.5
Tetrachloroethene (6)	8.5	840	139	0.0	0.1
Toluene	370	NA	330	NA	1.1
Trichloroethene (6)	16.5	21,900	450	0.0	0.04
Vinyl Chloride	11	NA	NA	NA	NA
Xylenes, total	240	NA	211	NA	1.1
LEACHATE SEEPS					
Inorganics					
Aluminum	4,040	NA	NA	NA	NA
Arsenic	8.3	48	190	0.2	<0.05
Barium	453	NA	4,100	NA	0.1
Cadmium	1.7	4.6	4.6	0.4	0.4
Calcium	121,000	NA	NA	NA	NA
Chromium	12.5	893	904	0.0	<0.05
Cobalt	31.3	NA	19	NA	1.7
Copper	20.2	54.4	54.4	0.4	0.4
Iron	24,700	1,000	NA	24.7	NA
Lead	17.4	31	30.8	0.6	0.6
Magnesium	153,000	NA	NA	NA	NA
Manganese	2,260	NA	NA	NA	NA
Nickel	99.7	714	714	0.1	0.1
Potassium	345,000	NA	NA	NA	NA
Sodium	954,000	NA	NA	NA	NA
Vanadium	20.3	NA	103	NA	0.2
Zinc	213	481	481	0.4	0.4

TABLE 42

RISK CHARACTERIZATION FOR CHEMICAL CONSTITUENTS FOUND IN LEACHATE LAGOON AND LEACHATE SEEP SAMPLES: RMEs, WATER QUALITY CRITERIA, AND ENVIRONMENAL HAZARD QUOTIENTS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Constituent	RME (1) (1g/L)	Chronic Aquatic Life Water Qaulity Criteria		EHQ (4)	
		(federal)(2) (1g/L)	(state) (3) (1g/L)	(federal)	(state)
LEACHATE SEEPS, CONT'D.					
Organics					
Acetone	16	NA	86,000	NA	<0.05
Benzene	7.2	NA	128	NA	0.1
bis(2-Ethylhexyl)Phthalate (6)	1	3	909	0.3	<0.05
4-Chloro-3-Methylphenol	2	NA	NA	NA	NA
Chlorobenzene (6)	9	50	236	0.2	<0.05
Chloroethane	11.2	NA	NA	NA	NA
1,4-Dichlorobenzene	8.5	763	146	0.0	0.1
Ethylbenzene	87	NA	580	NA	0.2
2-Methylnaphthalene	2	NA	NA	NA	NA
4-Methylphenol	1	NA	NA	NA	NA
Naphthalene (6)	13	620	43	0.0	0.3
Toluene	5	NA	330	NA	<0.05
Xylenes, total	150	NA	211	NA	0.7

1) RME = Reasonable Maximum Exposure
2) Quality Criteria for Water Update #2 (USEPA, 1987).
3) Pennsylvania Code, Title 25, Chapter 16, Subchapter A, Appendix A Table 1: Guidelines for Development of Criteria for Toxic Substances and Water Quality Criteria for Toxic Substances.
4) EHQ = Environmental Hazard Quotient
5) NA = Not Available
6) Insufficient data are available to develop criteria for federal standards; therefore, Lowest Observed Effect Levels (LOEL) are presented according to Quality Criteria for Water Update #2 (USEPA, 1987).

Notes: Federal Quality Criteria for Water and Pennsylvania Surface Water Criteria for Toxic Substances include hardness-dependent standards for protection of aquatic life as follows:

cadmium = °((0.7852°(ln(ppm hardness)))-3.490)
chromium = 11+°((0.819°(ln(ppm hardness)))+1.561)
copper = °((0.8545°(ln(ppm hardness)))-1.465)
lead = °((1.266°(ln(ppm hardness)))-4.661
nickel = °((0.846°(ln(ppm hardness)))_1.1645)
zinc = °((0.8473°(ln(ppm hardness)))+0.76140)

A value of 596 ppm hardness, obtained from the leachate sample L1N1A, was used to calculate surface water standards for cadmium, chromium, copper, lead, nickel, and zinc as shown in this table.

EPA REGION III
SUPERFUND DOCUMENT MANAGEMENT SYSTEM

DOC ID 103037
PAGE # 303558

IMAGERY COVER SHEET
UNSCANNABLE ITEM

SITE NAME Berks Landfill

OPERABLE UNIT 00

ADMINISTRATIVE RECORDS- SECTION ____ VOLUME III K

REPORT OR DOCUMENT TITLE Final Baseline Risk Assessment

DATE OF DOCUMENT 7/1/96

DESCRIPTON OF IMAGERY Site Map

NUMBER AND TYPE OF IMAGERY ITEM(S) 1, Unscannable Map

APPENDIX A

SUMMARY OF BRA PROCEDURES APPROVED BY USEPA REGION III

Golder Associates Inc.

305 Fellowship Road, Suite 200
Mt. Laurel, NJ USA 08054
Tel: (609) 273-1110
Fax (609) 273-0778

Golder Associates

January 20, 1994

Project No.: 913-6773

USEPA Region III
841 Chestnut Street
Mailcode: 3HW22
Philadelphia, PA 19107

Attn: Mr. Anthony Koller

RE: BASELINE RISK ASSESSMENT,
BERKS LANDFILL SITE

Dear Mr. Koller:

This letter summarizes our conference call on January 14, 1994. Also participating in our call were Ms. Nancy Rios (toxicologist, USEPA) and Mr. Femi Adeshina (toxicologist, Golder). Topics discussed and decisions agreed to regarding the baseline risk assessment (BRA) are as follows:

- With respect to lines of communication, Mr. Adeshina will contact Ms. Rios directly with technical questions concerning the risk assessment.

- As per the USEPA approved Work Plan, Golder will use EPA Region III guidance entitled "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening" (EPA/903/R-93/001) for selecting constituents of potential concern (COPC) at the Site.

- COPC for groundwater, soil, and air will be based on the tabulated screening values presented in the EPA Region III guidance.

- Because the majority of the Site, including the landfill areas, is currently designated industrial use (Berks County Planning Commission, December 1991), and because all on-site soil samples are from the landfill areas, the commercial/industrial screening values in the EPA Region III guidance will be used for selecting COPC in soil.

- The screening values to be used for selecting COPC in sediment will be the same as those used for soil.

- The EPA Region III guidance does not provide COPC screening values for surface water, leachate seepage, and lagoon water. Golder will develop values for these media based on the approach presented in the EPA Region III guidance for establishing screening values in the other media. The exposure to be considered when assessing the COPC screening values for surface water, leachate seepage, and lagoon water is dermal contact during potential wading and/or trespassing activities. Human ingestion of fish and incidental ingestion are not considered appropriate because the small creek and drainageways in question do not support a sport fishery nor are they deep enough for swimming or bathing.

- Federal ambient water quality criteria will be used to assess potential impacts to aquatic life during the environmental risk assessment.

In addition to the risk assessment topics, other issues regarding the project were discussed and agreed to during this and a subsequent telephone call, as presented below.

- The parameters of analyses for the next round (third quarter, Phase 1B) of residential well sampling (scheduled for the week of January 24, 1994) will be volatile organic compounds (VOCs) for all wells. Samples for semi-volatile organic compounds and metals will not be collected.

- Because the Nein residence had burned down and the well is presently not operational, this well will not be sampled.

- Trenching operations during the investigation of drums northwest of the western landfill will be conducted using Level B personnel protection. Based on air monitoring results using photoionization detector (PID) instruments, downgrades of the level of protection will be made for non-trenching activities such as removal of surface debris and containers and inspections and backfilling of the trench.

- Ambient air monitoring during trenching activities will be made using portable PID instruments. Should VOCs be detected during trenching, the downwind extent of the VOCs will be assessed. Other ambient air perimeter monitoring will not be performed.

We appreciate the opportunity to discuss and resolve these matters with USEPA. Please do not hesitate to call if you have questions.

Very truly yours,

GOLDER ASSOCIATES INC.

Femi Adeshina, Ph.D.
Senior Toxicologist

Randy 1 White

Randolph S. White, P.E.
Associate

FA/RSW:lrl

cc: Nancy Rios, USEPA
M. Rosenberg, PADER
R. Klinikowski, PADER
R. Bishop, PADER
Berks Landfill Respondents

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
841 Chestnut Building
Philadelphia, Pennsylvania 19107-4431

April 11, 1994

RECEIVED
APR 12 1994
GOLDER - NJ

Mr. Randy White, P.E.
Senior Project Manager
Golder Associates Inc.
305 Fellowship Road, Suite 200
Mt. Laurel, New Jersey 08054

Re: Berks Landfill - Interim Deliverables No. 1 and 2
Baseline Risk Assessment

Dear Mr. White:

I am enclosing the comments from EPA's toxicologist, Nancy Rios, on the following interim deliverables for the baseline risk assessment:

1. Interim Deliverable No. 1 - Selection of Contaminants of Potential Concern;

2. Interim Deliverable No. 2 - Exposure Pathways and Receptors

An additional comment, received from the Pennsylvania Department of Environmental Resources, questioned Table 4 in Interim Deliverable No. 2. In the equation, the chemical concentration used is that of water. Should not the chemical concentration in air be used instead?

If you have any questions, or should request a conference call with to discuss these comments, please call me at (215) 597-3923.

Sincerely,

Anthony F. Koller, P.E.
Remedial Project Manager

cc: Nancy Rios, EPA
Ron Klininowski, PADER
Ruth Bishop, PADER
Murray Rosenberg, CH2M HILL

AR303562

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
841 Chestnut Building
Philadelphia, Pennsylvania 19107

SUBJECT: Berks Landfill
Interim Deliverable No. 1-
Selection of COPC
Interim Deliverable No. 2-
Exposure Pathways and Receptors

DATE: 4-7-94

FROM: Nancy Rios, Toxicologist
Technical Support Section (3HW13)

TO: Tony Koller, RPM
SE PA Remedial Section (3HW21)

I have reviewed the subject documents and have the following comments:

I. Interim Deliverable No. 1: Selection of Contaminants of Potential Concern

<u>Development of Data Summary Statistics</u>

- Data qualified A, K or L should not be included in the assessment of contaminants of potential concern (COPCs). Only J qualified data are used.

- One half of the reported value for B (blank) qualified data should not be used in the calculation of summary statistics when the contaminant has been verified present in the submedia by another sample result.

- Samples where SQLs or CRDLs exceeded twice the maximum detected concentrations in that media should not be excluded from the calculation of the mean concentration.

<u>Screening Guidance</u>

- The incorrect guidance was used for screening of COPCs. The correct guidance is "Selecting Exposure Routes and Contaminants of Concern by Risk-based Screening." (see attachment)

- Please rescreen the COPCs using the attached guidance. Note that the risk-based concentration for arsenic (carcinogen) should be used, not the non-carcinogenic risk-based concentration.

Determination of Screening Concentrations

- The target hazard quotient used for screening is 0.1, not 1.
- The exposure time of 20 mins (or 0.3 hr/day) should be changed to 2.4 hours/day to be consistent with Regional policy regardless of whether significant wading activities occur.
- The exposure frequency of 18 days/year can be changed to 7 days/year (instead of 18 days/year) as recommended in the Risk Assessment Guidance for Superfund (RAGS).

COPCs for Ground Water

Chemical constituents with less than 5% detection frequency can only be eliminated if the database is large. What constitutes a large database is determined statistically. Otherwise, all organic contaminants (especially in ground water) are carried through the assessment.

COPCs for Surface Soil/Sediment

The issue regarding hazardous levels of beryllium in both the on-site surface soil (or sediment) samples and background samples is understood. However, please be aware that if beryllium is a site-related contaminant, it must still be carried through the risk assessment; although, cleanup levels later may be set at the background level if there appears to be no significant difference between the background and the on-site levels. Note that if beryllium is a site-related contaminant, cleanup to the risk-based concentration for beryllium may still be necessary. This then becomes a risk-management decision.

II. Interim Deliverable No. 2: Exposure Pathways and Receptors

On-Site Trespassers

The region typically defines a trespasser on surface soil as being an adolescent which weighs 55 kg and ingests 100 mg/day of the contaminated media 50 days/year for a period of 6 years. In the case of surface water, an exposure period of 7 days/year, 2.4 hours/day is assumed.

On-Site Workers

Please provide data justifying the assumption that workers on-site will not work more than 24 days/year.

Ground Water Exposure Factors

Dermal Contact (Showering) With Ground Water

The dermal exposure pathway is assumed for a child during bathing only, not during showering. It is assumed that the child will bathe 6 years and the adult will shower for 24 years.

Inhalation of Vapors (Showering)

Please use the Foster and Chrostowski Shower Model (1987) to calculate the concentration term. (see attachment)

Soil and Sediment Exposure Factors

Ingestion of Soil/Sediment

Please use exposure parameters for an adolescent trespasser as defined above for soil.

Dermal Contact With Soil and Sediment

Please use exposure parameters for an adolescent trespasser as defined above for soil. Note that the soil to skin adherence factor specified in the Dermal Guidance is 1.00 mg/cm^2, not 1.45 mg/cm^2. Region III does not recommend using the default dermal absorption factors noted in the Report at this time. Please use only the available dermal absorption factors for cadmium, dioxins and PCBs in the Dermal Guidance.

Dermal Contact With Environmental Media

Please use exposure parameters for an adolescent trespasser as defined above for surface water. Note that surface area for each body part will need to be modified accordingly.

Exposure Factors for Inhalation of Airborne Chemicals

The exposure times for the off-site resident and trespasser need to be redefined based on the type of outdoor activity expected. A default exposure time of 2-3 hours/day for the off-site resident and 2.4 hours/day for the trespasser is acceptable.

<u>General Comments</u>

Please attached the raw data and sample calculations of the mean concentration in an Appendix to the Report.

I have no further comments at this time. Please let me know if you need further assistance.

Attachments

cc: E. Johnson (3HW13) w/o attachments
B. Rundell (3HW13) w/o attachments

Golder Associates Inc.

305 Fellowship Road, Suite 200
Mt. Laurel, NJ USA 08054
Tel: (609) 273-1110
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Golder Associates

May 23, 1994

Project No.: 913-6773

USEPA Region III
841 Chestnut Street
Mailcode: 3HW22
Philadelphia, PA 19107

Attn: Mr. Anthony Koller

RE: BASELINE RISK ASSESSMENT,
BERKS LANDFILL SITE

Dear Mr. Koller:

This letter summarizes our telephone conference call on May 3, 1994, to discuss the USEPA review comments on the Baseline Risk Assessment (BRA) Interim Deliverable Nos. 1 and 2 reports. Also participating in the discussions were Ms. Nancy Rios (toxicologist, USEPA) and Dr. Femi Adeshina (toxicologist, Golder). Our understanding of USEPA directives for performing the BRA are outlined below.

- Data qualified B, K or L (as defined by USEPA Region III guidance for data validation) should not be included in the selection of chemicals of potential concern (COPCs). Only the maximum detected values of A (acceptable) and J qualified data should be used.

- Data qualified B should not be used in the performance of the BRA.

- Data qualified U, UJ, UL, K or L should be used in the BRA at the one-half SQL or CRDL value.

- Samples with unusually high SQLs or CRDLs should not be eliminated from the BRA.

- The exposure time of 2.4 hours/day should be used in the BRA for potential trespassers at the Site in accordance with USEPA Region III policy.

- In accordance with USEPA Region III policy, chemical constituents in groundwater media with less than 5% detection frequency should not be eliminated from the BRA.

- In the case of beryllium, risk estimates should be determined separately for background and Site-related concentrations in surface soil and sediment.

- Information to justify that future maintenance workers at the Site will not work for more than 24 days/year may be provided by using USEPA-approved landfill operation and maintenance plans.

- The exposure time of 0.44 hr/day may be used in the BRA for off-site residents during outdoor activities (such as home maintenance, gardening, etc.) as recommended in the USEPA "Exposure Factors Handbook."

- The USEPA would provide Golder Associates with a copy of Region III guidance manual on SQLs and CRDLs.

- There would be no additional USEPA directives, comments, or guidance on Golder Associates' approach for conducting the BRA, especially in regard to the use of qualified data and calculations of summary statistics.

- It will not be necessary to submit revisions to Interim Deliverable Nos. 1 and 2 to the USEPA for review. Rather, the BRA report will be submitted to the Agency for review when completed.

In a follow-up telephone discussion between Ms. Nancy Rios (USEPA Toxicologist) and Dr. Femi Adeshina (Golder Toxicologist) on May 12, 1994, the USEPA has further directed the following:

- Analytical data qualified as K or L should be included in the determination of frequency of detection count.

- For reanalyzed samples, the higher of reported values should be used in the BRA.

- For duplicated samples, the average (arithmetic mean) of reported values should be used.

- Risk estimates should be determined separately for background and Site-related concentrations of detected inorganic chemicals (metals) in groundwater.

Golder further understands that USEPA concurs with the identified exposure pathways and exposure factors presented in BRA Interim Deliverable No. 2, with the exception of those discussed and agreed to in this letter. In view of the extent of USEPA directives, and the required use of the latest Region III guidance manual (for selecting COPCs dated March 18, 1994) in performing the BRA, Golder proposes to complete the risk assessment and submit a draft report for Agency review on or before August 15, 1994.

Golder is prepared to proceed with the Feasibility Study (FS) for the Berks Site based on the proposed BRA schedule. Accordingly, we will need to revise the FS schedule by two months (i.e., submit draft report to USEPA on November 31, 1994). However, it should be emphasized that if significant USEPA comments on the BRA are received, the submittal of the FS report may be delayed.

We appreciate the opportunity to discuss and resolve these issues with the USEPA. Please do not hesitate to contact us if you have any questions.

Very truly yours,

GOLDER ASSOCIATES INC.

Femi Adeshina, Ph.D.
Senior Toxicologist

Randolph S. White, P.E.
Associate

FA/RSW:lrl

cc: Nancy Rios, USEPA
R. Klinikowski, PADER
R. Bishop, PADER
Berks Landfill Respondents

AR303569

APPENDIX B

CALCULATION OF RISK-BASED SCREENING CONCENTRATIONS

APPENDIX B

CALCULATION OF RISK-BASED SCREENING CONCENTRATIONS

Exposure Assumptions - Calculation of Risk-Based Screening Concentrations

A. Exposed Skin Surface Area

Dermal contact with the surface water, leachate water, and leachate seep water could occur if a child trespasser uses the water bodies for wading activities. It is assumed that the hands and legs could be exposed during wading activities at the Site.

B. Exposure Time

As directed by USEPA Region III, an exposure time of 2.4 hours/day is used for a potential trespasser at the Site for wading activities. It should, however, be particularly noted that the surface water bodies at the Site are relatively small and only contain water intermittently. Thus, they are considered unsuitable for either swimming or significant wading activities. Therefore, the use of this exposure time (i.e., 2.4 hrs/day) in the BRA is assumed to be very conservative.

Age-adjusted factor for dermal contact (DCFadj.) is =

$$ET\left(\frac{EDc}{BWc} * PC * SAc + \frac{(EDtot - EDc)}{BWa} * PC * SAa\right)$$

1. Carcinogens: Calculations are based on combined childhood and adult exposure.

Risk-based concentration (mg/L) =

$$\frac{TR * ATc}{EFr * \dfrac{DCFadj}{\left(\dfrac{1000\ cm^3}{1\ litre}\right)} * CSF_0}$$

2. Non-carcinogens: Calculations are based on childhood exposure only.

Risk-based concentration (mg/L) =

$$\frac{THQ * RfDo * BWc * ATn}{EFr * EDc * \dfrac{ET * PC * SAc}{\left(\dfrac{1000\ cm^3}{1\ litre}\right)}}$$

where:

TR	=	Target cancer risk (1E-06)
BWa; BWc	=	Body weight (70 kg and 15 kg, respectively, for adult and child)
Volumetric conversion factor for water is 1000 cm^3/1 liter		
SA_a; SA_c	=	Skin area (8,620 cm^2 and 3,910 cm^2, respectively, for adult and child hands and legs) (USEPA, 1989a).
EFr	=	Exposure frequency (7 days/yr at the Site)

EDtot	=	30 years for residential exposure scenario
EDc	=	Exposure duration, age 1 to 6 (yr)
ATc	=	Averaging time carcinogens (25,550 days)
ATn	=	Averaging time noncarcinogens (EDc * 365 days)
PC	=	Chemical-specific dermal permeability constant (cm/hr) (USEPA, 1992a)
ET	=	Exposure time (2.4 hr/day).
CSF_O	=	Oral carcinogenic slope factor (mg/kg-day)-1
THQ	=	Target hazard quotient (0.1)
RfD_O	=	Oral reference dose (mg/kg-day)

The calculated risk-based screening concentrations for surface water and leachate media are presented in Tables 15 and 17, respectively.

APPENDIX C

SHOWER INHALATION MODEL

APPENDIX C

SHOWER INHALATION MODEL

Inhalation of Contaminants Volatilized from Shower Water

In the model developed by Foster and Chrostowski (1986), inhalation exposures to volatile organic chemicals (VOCs) while showering are modeled by estimating the rate of chemical releases into the air (generation rate), the buildup of VOCs in the shower room air while the shower is on, the decay of VOCs in the shower room air after the shower is turned off, and the quantity of airborne VOCs inhaled while the shower is both on and off.

Estimation of the rate of VOC release into the air is based upon Liss and Slater's (1974) adaptation of the two-film gas-liquid mass transfer theory. The two-film boundary theory provides the basis for estimating the overall mass transfer coefficient (K_L) for each VOC of interest, according to the following equation:

$$K_L = (1/k_l + RT/Hk_g)^{-1} \qquad (1)$$

where:

K_L	=	overall mass transfer coefficient (centimeter per hour [cm/hr]);
H	=	Henry's law constant (atm-m^3/mol-K);
RT	=	2.4 x 10^{-2} atm-m^3/mole (gas constant of 8.2 x 10^{-5} atm-$^{-3}$/mole-K times absolute temperature of 293 K);
k_g	=	gas-film mass transfer coefficient (cm/hr); and,
k_l	=	liquid-film mass transfer coefficient (cm/hr).

Equation 1 describes the mass transfer rate of a compound at an air-water interface where diffusion may be limited by both liquid- and gas-phase resistances.

Typical values of k_l (20 cm/hr) and k_g (3,000 cm/hr), which have been measured for CO_2 and H_2O, respectively, may be used to estimate VOC-specific values for these parameters (Liss and Slater, 1974):

$$k_g\,(VOC) = k_g(H_2O(18/MW_{VOC})^{0.5} \qquad (2)$$

$$k_l\,(VOC) = k_l(CO_2(44/MW_{VOC})^{0.5} \qquad (3)$$

where:

MW = molecular weight (g/mol).

The mass transfer coefficient, K_L, is adjusted to the shower water temperature, T_S, according to a semi-empirical equation developed to estimate the effect of temperature on oxygen mass-transfer rate (O'Connor and Dobbins, 1956):

$$K_{aL} = K_L(T_l T_S / T_S T_l)^{-0.5} \quad (4)$$

where:

K_{aL}	=	adjusted overall mass transfer coefficient (cm/hr);
T_l	=	calibration water temperature of K_L (K);
T_S	=	shower water temperature (K);
T_l	=	water viscosity at T_l (cp); and,
T_S	=	water viscosity at T_S (cp).

The concentration leaving the shower droplet, C_{wd}, is obtained from an integrated rate equation based on a mass-balance approach:

$$C_{wd} = C_{wo}(1-\exp[-K_{aL}t_s/60d]) \quad (5)$$

where:

C_{wd}	=	concentration leaving shower droplet after time t_s(ug/l);
C_{wo}	=	shower water concentration (ug/l);
d	=	shower droplet diameter (mm); and,
t_s	=	shower droplet drop time (sec).

The term $K_{aL}/60d$ combines both the rate transfer and the available interfacial area across which volatilization can occur. The value 1/60d equals the specific interfacial area, 6/d, for a special shower droplet of diameter "d" multiplied by conversion factors (hr/3,600 sec and 10 mm/cm).

The VOC generation rate in the shower room, S, can then be calculated by the equation:

$$S = C_{wd}(Fr)/SV \quad (6)$$

where:

S	=	indoor VOC generation rate (ug/m^3-min);
FR	=	shower water flow rate (liter/min); and,
SV	=	shower room air volume (m^3).

A simple one-box indoor air pollution model was used to estimate VOC air concentrations in the shower room. This model can be expressed as a differential equation describing the rate of change of the indoor pollutant concentration with time:

$$dC_a/dt = RC_a + S \tag{7}$$

where:

C_a	=	indoor VOC air concentrations (ug/m^3); and,
R	=	air exchange rate (min^{-1}).

When Equation 7 is integrated, the time-dependent indoor concentration can be estimated as follows:

$$C_a(t) = (S/R)(1 - \exp[-Rt]) \text{ for } t \text{ £ } D_S$$

and

$$C_a(t) = (S/R)(\exp[RDs] - 1)(\exp[-Rt]) \text{ for } t \text{ £ } D_S$$

where:

$C_a(t)$	=	indoor air VOC concentration at time t (ug/m^3);
D_S	=	shower duration (min); and,
t	=	time (min).

The inhalation exposure per shower can then be calculated according to the equation:

$$E_{inh} = [VR/(BW)(10^6)] \int_0^{D_t} C_a(t)dt$$

where:

E_{inh}	=	inhalation exposure per shower (mg/kg/shower);
VR	=	ventilation rate (liter/min);
BW	=	body weight (kg); and,
D_t	=	total duration in shower room (min).

This equation can be solved as:

$$E_{inh} = (VR)(S)/[(BW)(R)(10^6)] [(D_S - 1/R + \exp(RD_S)/R]$$

for the duration of the shower, and as

$$E_{inh} = (VR)(S)/[(BW)(R)(10^6)] \times \left[D_s + \left(\frac{\exp(-RD_t)}{R} - \frac{[\exp[R(D_s - D_t)]}{R}\right)\right]$$

for both the duration of the shower and the duration in the room after the shower is turned off.

Assuming that an individual showers daily, E_{inh} is then equivalent to the chronic daily intake for chemicals of interest.

The input parameters for the shower model are listed in Table B-1.

REFERENCES

Foster, S.A., and P.C. Chrostowski, 1986. "Integrated Household Exposure Model for Use of Tap Water Contaminated with Volatile Organic Chemicals," presented at the 79th Annual Meeting of the Air Pollution Control Association, Minneapolis, Minnesota, June 22-27, 1986.

Liss, P.S., and P.G. Slater, 1974. "Flux of Gases Across the Air-Sea Interface," Nature 247:181-184.

O'Connor, D.J., and W. Dobbins, 1956. "The Mechanics of Reaeration in Natural Streams," J. Sanit, Eng. Div., ASCE 82:SA6, in Shroeder, E.D., Water and Wastewater Treatment, Chapter 4: Gas Transfer, McGraw-Hill, 1977.

TABLE C-1
PARAMETERS USED IN THE CALCULATION OF INTAKES FROM VOLATILIZATION WHILE SHOWERING

PARAMETER	UNIT	VALUE
Calibration water temperature, T_1	K	293
Shower water temperature, T_S	K	318
Water viscosity at T_1, u_1	Centipoise	1.002
Water viscosity at T_S, u_S	Centipoise	0.596
Shower water droplet diameter, d	mm	1.0
Shower droplet drop time, t_S	sec	2
Shower water flow rate, FR	liter/min	20
Shower stall air volume, SV	m^3	2.9E+00
Air exchange rate, R	min^{-1}	0.0167
Shower duration, D_S	min	12
Total duration in shower room, D_t	min	15
Ventilation rate, VR (adult)	liter/min	10
Body weight, BW (adult)	kg	70

APPENDIX D

ATMOSPHERIC TRANSPORT MODELS

Determination of Chemical Emission Rates and Modeled Concentrations for On-Site Workers, On-Site Trespassers, and Off-Site Residents

APPENDIX D

ATMOSPHERIC TRANSPORT MODELS

DETERMINATION OF CHEMICAL EMISSION RATES
AND MODELED CONCENTRATIONS FOR
ON-SITE WORKERS, ON-SITE TRESPASSERS
AND OFF-SITE RESIDENTS

ESTIMATING VOLATILIZATION OF CHEMICALS IN LANDFILL (USEPA, 1988)

Equation $$E_i = C_i * V_y * A \quad (1)$$

Where:

E_i	=	emission rate (mg/sec.)
C_i	=	calculated RME from passive landfill vent gasses (mg/m^3)
V_y	=	gas velocity of 1.63E-056 m/sec.
A	=	area of both east and west landfills of 2.67-~~67~~E+056 m^2 (Golder, 1994)

The estimated emission rates, based on RME concentrations, for the chemicals of interest are listed in Table D-1.

ESTIMATING ON-SITE AIR CONCENTRATIONS USING THE BOX MODEL (USEPA, 1988)

Equation $$C = (E_i / (r * u * L)) \quad (2)$$

Where:

C	=	chemical concentration in air (mg/m^3)
E_i	=	emission rate (mg/sec.); calculated in Equation (1) above
r	=	atmospheric mixing height of 3.00E+02 m (USEPA, 1972)
u	=	average wind speed of 2.2 m/sec.; estimated from Harrisburg Airport wind rose data (NOAA, 1944)
L	=	length of soil area of 617 m; estimated from Figure 3-2 (Golder, 1994)

The output of the box model for each chemical of interest in listed in Table D-1.

ESTIMATING AIR CONCENTRATIONS USING GAUSSIAN DISPERSION MODEL (USEPA, 1988)

Equation $C(x) = Q / (pi * {}_{sigma}Y * {}_{sigma}Z * u)$ (3)

Where:

$C(x)$	=	chemical concentration (mg/m^3); This represents the estimated distance of 0.33 km from center of Site to eastern fenceline based on Class C–D stability in nomographs.
Q or E_i	=	flux at the source (mg/m^3); calculated in Equation
pi	=	3.141593
${}_{sigma}Y$	=	dispersion coefficient in the lateral (crosswind) direction (24 m)
${}_{sigma}Z$	=	dispersion coefficient in the vertical direction (13 m)
u	=	mean wind speed (of 2.2 m/sec.); estimated from Harrisburg Airport wind rose data

The output of the air dispersion model for each chemical of interest is presented in Table D-1.

REFERENCES

NOAA, 1994. Local Climatological Data for Harrisburg, PA., U.S. Dept. of Commerce, Environmental Data Service.

U.S.EPA, 1972. "Mixing Heights and Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous U.S.," Office of Air Programs Division of Meteorology, Research Triangle Park, NC PB-207103.

U.S.EPA, 1988. Superfund Exposure Assessment Manual, Office of Remedial Response, Washington, D.C., EPA/540/1-88/001, April 1988.

TABLE D-1
CHEMICALS DETECTED IN PASSIVE VENTS
AIR EMISSIONS MODELING
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

Chemicals of Concern	RME Concentration (mg/m^3)	Emission Rate (mg/sec)	Box Model for On-Site Workers and Trespassers VOC Concentration (mg/m^3)	Dispersion Model for Off-Site and On-Site Residents VOC Concentration (mg/m^3)
Benzene	0.92	4.00E+00	9.83E-06	1.86E-03
Chlorobenzene	1.2	5.22E+00	1.28E-05	2.42E-03
Chloroethane	1.6	6.96E+00	1.71E-05	3.23E-03
Dichlorodifluoromethane	6.6	2.87E+01	7.05E-05	1.33E-02
cis-1,2-Dichloroethene	4.3	1.87E+01	4.60E-05	8.68E-03
Ethylbenzene	140	6.09E+02	1.50E-03	2.83E-01
Hydrogen Sulfide	18.04	7.85E+01	1.93E-04	3.64E-02
Toluene	68	2.96E+02	7.27E-04	1.37E-01
Trichloroethene	2.1	9.14E+00	2.24E-05	4.24E-03
1,2,4-Trimethylbenzene	21	9.14E+01	2.24E-04	4.24E-02
1,3,5-Trimethylbenzene	12	5.22E+01	1.28E-04	2.42E-02
Vinyl Chloride	15	6.53E+01	1.60E-04	3.03E-02
Total Xylenes	330	1.44E+03	3.53E-03	6.66E-01

APPENDIX E

CALCULATION OF CANCER RISKS AND HAZARD INDICES

06/17/96
02:31 PM
1-BKMETALA.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Ingestion of Chemical Constituents in Background Groundwater

Receptor: ADULT

Intake = (CW * IR * EF * ED)/(BW * AT)
(mg/kg/day)

Cancer Risk = Intake (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Intake (mg/kg/day) / fD (mg/kg/day)

WHERE:
CW = CONCENTRATION OF CONSTITUENT IN WATER (mg/l)
IR = INGESTION RATE (l/day)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATION (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME = ED X 365 days for noncarcinogens; or 70 yrs (lifetime exposure) X 365 days for carcinogens

Constituent	"CW" Concentration (mg/l)	"IR" Ingestion Rate (l/day)	"EF" Expos. Freq. (days/year)	"BW" Body Weight (kg)	Lifetime Exposure (years)	"AT" Averaging Time (days)	"ED" Exposure Duration (years)	Intake (mg/kg/day)	Oral CSF (mg/kg/day)^-1	Cancer Risk	Oral RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens												
Arsenic	0.008	2	350	70	70	25550	24	7.51E-05	1.7E+00	1.28E-04	NA	NA
Beryllium	0.003	2	350	70	70	25550	24	2.82E-05	4.3E+00	1.21E-04	NA	NA
Noncarcinogens												
Aluminum	58.300	2	350	70	NA	8760	24	1.60E+00	NA	NA	1.0E+00	1.60E+00
Arsenic	0.008	2	350	70	NA	8760	24	2.19E-04	NA	NA	3.0E-04	7.31E-01
Barium	0.173	2	350	70	NA	8760	24	4.74E-03	NA	NA	7.0E-02	6.77E-02
Beryllium	0.003	2	350	70	NA	8760	24	8.22E-05	NA	NA	5.0E-03	1.64E-02
Cadmium	0.007	2	350	70	NA	8760	24	1.92E-04	NA	NA	5.0E-04	3.84E-01
Copper	0.272	2	350	70	NA	8760	24	7.45E-03	NA	NA	3.7E-02	2.01E-01
Manganese	1.240	2	350	70	NA	8760	24	3.40E-02	NA	NA	5.0E-03	6.79E+00
Nickel	0.036	2	350	70	NA	8760	24	9.86E-04	NA	NA	2.0E-02	4.93E-02
Vanadium	0.156	2	350	70	NA	8760	24	4.27E-03	NA	NA	7.0E-03	6.11E-01
									SUMMATION:	2.49E-04		1.05E+01

Notes:
NA = Not Applicable
ND = Not Determined

AR303586

06/17/96
02:32 PM
2-BKMETALC.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Ingestion of Chemical Constituents in Background Groundwater

Receptor: CHILD

Intake = (CW * IR * EF * ED)/(BW * AT)
(mg/kg/day)

Cancer Risk = Intake (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Intake (mg/kg/day) / RfD (mg/kg/day)

WHERE:
CW = CONCENTRATION OF CONSTITUENT IN WATER (mg/l)
IR = INGESTION RATE (l/day)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATION (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME = ED X 365 days for noncarcinogens; or 70 yrs (lifetime exposure) X 365 days for carcinogens.

Constituent	"CW" Concentration (mg/l)	"IR" Ingestion Rate (l/day)	"EF" Expos. Freq. (days/year)	"BW" Body Weight (kg)	Lifetime Exposure (years)	"AT" Averaging Time (days)	"ED" Exposure Duration (years)	Intake (mg/kg/day)	Oral CSF (mg/kg/day)^-1	Cancer Risk	Oral RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens												
Arsenic	0.008	1	350	15	70	25550	6	4.38E-05	1.7E+00	7.45E-05	NA	NA
Beryllium	0.003	1	350	15	70	25550	6	1.64E-05	4.3E+00	7.07E-05	NA	NA
Noncarcinogens												
Aluminum	58.300	1	350	15	NA	2190	6	3.73E+00	NA	NA	1.0E+00	3.7E+00
Arsenic	0.008	1	350	15	NA	2190	6	5.11E-04	NA	NA	3.0E-04	1.7E+00
Barium	0.173	1	350	15	NA	2190	6	1.11E-02	NA	NA	7.0E-02	1.6E-01
Beryllium	0.003	1	350	15	NA	2190	6	1.92E-04	NA	NA	5.0E-03	3.8E-02
Cadmium	0.007	1	350	15	NA	2190	6	4.47E-04	NA	NA	5.0E-04	8.9E-01
Copper	0.272	1	350	15	NA	2190	6	1.74E-02	NA	NA	3.7E-02	4.7E-01
Manganese	1.240	1	350	15	NA	2190	6	7.93E-02	NA	NA	5.0E-03	1.6E+01
Nickel	0.036	1	350	15	NA	2190	6	2.30E-03	NA	NA	2.0E-02	1.2E-01
Vanadium	0.156	1	350	15	NA	2190	6	9.97E-03	NA	NA	7.0E-03	1.4E+00
									SUMMATION:	1.45E-04		2.44E+01

Notes:
NA = Not Applicable
ND = Not Determined

AR303587

06/17/96
02:32 PM
3-DMBBKMC.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Dermal Contact with Chemical Constituents in Background Groundwater while Bathing

Receptor: CHILD

Absorbed Dose (mg/kg/day) = (CW * SA * PC * ET * EF * ED * CFv)/(BW * AT)

Cancer Risk = Absorbed Dose (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Absorbed Dose (mg/kg/day) / RfD (mg/kg/day)

WHERE:
CW = CONCENTRATION OF CONSTITUENT IN WATER (mg/l)
SA = SKIN SURFACE AREA (cm^2)
PC = CHEMICAL-SPECIFIC DERMAL PERMEABILITY CONSTANT (cm/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
CFv = VOLUMETRIC CONVERSION FACTOR (1 liter/1000 cm^3)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME = ED X 365 days from noncarcinogens; or 70 yrs (lifetime exposure) X 365 days for carcinogens.

Constituent	"CW" Concentration (mg/l)	"SA" Skin Area (cm^2)	"ET" Exp. Time (hr/day)	"PC" Permeability Constant (cm/hr)	"EF" Expos. Freq (days/year)	"BW" Body Weight (kg)	Lifetime Exposure (years)	"AT" Averaging Time (days)	"ED" Exposure Duration (years)	Absorbed Dose (mg/kg/day)	Dermal CSF (mg/kg/day)^-1	Cancer Risk	Dermal RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens														
Arsenic	0.008	7280	0.2	1.6E-04	350	15	70	25550	6	1.02E-08	2.80E+00	2.86E-08	NA	NA
Beryllium	0.003	7280	0.2	1.6E-04	350	15	70	25550	6	3.83E-09	4.30E+02	1.65E-06	NA	NA
Noncarcinogens														
Aluminum	58.300	7280	0.2	1.6E-04	350	15	NA	2190	6	8.68E-04	NA	NA	1.50E-01	5.79E-03
Arsenic	0.008	7280	0.2	1.6E-04	350	15	NA	2190	6	1.19E-07	NA	NA	1.80E-04	6.62E-04
Barium	0.173	7280	0.2	1.6E-04	350	15	NA	2190	6	2.58E-06	NA	NA	3.50E-02	7.36E-05
Beryllium	0.003	7280	0.2	1.6E-04	350	15	NA	2190	6	4.47E-08	NA	NA	5.00E-05	8.94E-04
Cadmium	0.007	7280	0.2	1.0E-03	350	15	NA	2190	6	6.52E-07	NA	NA	2.50E-04	2.61E-03
Copper	0.272	7280	0.2	1.6E-04	350	15	NA	2190	6	4.05E-06	NA	NA	3.59E-02	1.13E-04
Manganese	1.240	7280	0.2	1.6E-04	350	15	NA	2190	6	1.85E-05	NA	NA	2.00E-04	9.23E-02
Nickel	0.036	7280	0.2	1.0E-04	350	15	NA	2190	6	3.35E-07	NA	NA	2.00E-03	1.68E-04
Vanadium	0.156	7280	0.2	1.6E-04	350	15	NA	2190	6	2.32E-06	NA	NA	7.00E-03	3.32E-04
											SUMMATION:	1.68E-06		1.03E-01

Notes:
NA = Not Applicable
ND = Not Determined

AR303588

06/17/96
02:37 PM
4-INGBKSMC.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Incidental Ingestion of Chemical Constituents in Background Soil

Receptor: CHILD

Intake (mg/kg/day) = (CS * IR * FI * BF * CF * EF * ED)/(BW * AT)

Cancer Risk = Intake (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Intake (mg/kg/day) / RfD (mg/kg/day)

WHERE:
CS = CONCENTRATION OF CONSTITUENT IN SOIL (mg/kg)
IR = INGESTION RATE (mg/day)
FI = FRACTION INGESTED FROM CONTAMINATED SOURCE (100%)
CF = CONVERSION FACTOR (1E-06 kg/mg)
BF = BIOAVAILABILITY FACTOR (1, unitless)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATON (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME = ED X 365 days for noncarcinogens; or 70 yrs (lifetime exposure) X 365 days for carcinogens.

Constituent	"CS" Concentration (mg/kg)	"IR" Ingest. Rate (mg/day)	"FI" Fraction Ing. (unitless)	"EF" Exp. Freq. (days/yr)	"ED" Exp. Duration (years)	"BW" Body Wt. (kg)	Lifetime Exposure (years)	"AT" Averaging Time (days)	Intake (mg/kg/day)	Oral CSF (mg/kg/day)^-1	Cancer Risk	Oral RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens													
Beryllium	1.50	100	1	50	9	55	70	25,550	4.80E-08	4.3E+00	2.07E-07	NA	NA
Noncarcinogens													
Beryllium	1.50	100	1	50	9	55	NA	3,285	3.74E-07	NA	NA	5.0E-03	7.47E-05
										SUMMATION:	2.07E-07		7.47E-05

Notes:
NA = Not Applicable
ND = Not Determined

AR303589

06/17/96
02:53 PM
5-INGGOFRA.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Ingestion of Chemical Constituents in Off-Site Residential Groundwater

Receptor: ADULT

Intake (mg/kg/day) = (CW * IR * EF * ED)/(BW * AT)

Cancer Risk = Intake (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Intake (mg/kg/day) / RfD (mg/kg/day)

WHERE:
CW = CONCENTRATION OF CONSTITUENT IN WATER (mg/l)
IR = INGESTION RATE (l/day)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATION (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME = ED X 365 days for noncarcinogens; or 70 yrs (lifetime exposure) X 365 days for carcinogens.

Constituent	"CW" Concentration (mg/l)	"IR" Ingestion Rate (l/day)	"EF" Expos. Freq. (days/year)	"BW" Body Weight (kg)	Lifetime Exposure (years)	"AT" Averaging Time (days)	"ED" Exposure Duration (years)	Intake (mg/kg/day)	Oral CSF (mg/kg/day)^-1	Cancer Risk	Oral RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens												
Chloroform	0.001	2	350	70	70	25550	24	9.39E-06	6.1E-03	5.73E-08	NA	NA
1,2-Dichloroethane	0.001	2	350	70	70	25550	24	9.39E-06	9.1E-02	8.55E-07	NA	NA
1,1,2-Trichloroethane	0.001	2	350	70	70	25550	24	9.39E-06	5.7E-02	5.35E-07	NA	NA
Arsenic	0.006	2	350	70	70	25550	24	5.64E-05	1.7E+00	9.58E-05	NA	NA
Noncarcinogens												
Chloroform	0.001	2	350	70	NA	8760	24	2.74E-05	NA	NA	1.0E-02	2.74E-03
1,2-Dichloroethane	0.001	2	350	70	NA	8760	24	2.74E-05	NA	NA	ND	ND
1,1,2-Trichloroethane	0.001	2	350	70	NA	8760	24	2.74E-05	NA	NA	4.0E-03	6.85E-03
Arsenic	0.006	2	350	70	NA	8760	24	1.64E-04	NA	NA	3.0E-04	5.48E-01
									SUMMATION:	9.73E-05		5.58E-01

Notes:
NA = Not Applicable
ND = Not Determined

AR303590

06/17/96
02:54 PM
6-INGGOFRC.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Ingestion of Chemical Constituents in Off-Site Residential Groundwater

Receptor: CHILD

Intake (mg/kg/day) = (CW * IR * EF * ED)/(BW * AT)

Cancer Risk = Intake (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Intake (mg/kg/day) / RfD (mg/kg/day)

WHERE:
CW = CONCENTRATION OF CONSTITUENT IN WATER (mg/l)
IR = INGESTION RATE (l/day)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATION (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME = ED X 365 days for noncarcinogens; or 70 yrs (lifetime exposure) X 365 days for carcinogens.

Constituent	"CW" Concentration (mg/l)	"IR" Ingestion Rate (l/day)	"EF" Expos. Freq. (days/year)	"BW" Body Weight (kg)	Lifetime Exposure (years)	"AT" Averaging Time (days)	"ED" Exposure Duration (years)	Intake (mg/kg/day)	Oral CSF (mg/kg/day)^-1	Cancer Risk	Oral RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens												
Chloroform	0.001	1	350	15	70	25550	6	5.48E-06	6.1E-03	3.34E-08	NA	NA
1,2-Dichloroethane	0.001	1	350	15	70	25550	6	5.48E-06	9.1E-02	4.99E-07	NA	NA
1,1,2-Trichloroethane	0.001	1	350	15	70	25550	6	5.48E-06	5.7E-02	3.12E-07		
Arsenic	0.006	1	350	15	70	25550	6	3.29E-05	1.7E+00	5.59E-05	NA	NA
Noncarcinogens												
Chloroform	0.001	1	350	15	NA	2190	6	6.39E-05	NA	NA	1.0E-02	6.39E-03
1,2-Dichloroethane	0.001	1	350	15	NA	2190	6	6.39E-05	NA	NA	ND	ND
1,1,2-Trichloroethane	0.001	1	350	15	NA	2190	6	6.39E-05	NA	NA	4.0E-03	1.60E-02
Arsenic	0.006	1	350	15	NA	2190	6	3.84E-04	NA	NA	3.0E-04	1.28E+00
									SUMMATION:	5.67E-05		1.30E+00

Notes:
NA = Not Applicable
ND = Not Determined

AR303591

06/17/96
02:55 PM
7-DMBTHOFC.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Dermal Contact with Chemical Constituents in Off-Site Residential Groundwater while Bathing

Receptor: CHILD

Absorbed Dose (mg/kg/day) = (CW * SA * PC * ET * EF * ED * CFv)/(BW * AT)

Cancer Risk = Absorbed Dose (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Absorbed Dose (mg/kg/day) / RfD (mg/kg/day)

WHERE:
CW = CONCENTRATION OF CONSTITUENT IN WATER (mg/l)
SA = SKIN SURFACE AREA (cm^2)
PC = CHEMICAL-SPECIFIC DERMAL PERMEABILITY CONSTANT (cm/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
CFv = VOLUMETRIC CONVERSION FACTOR (1 liter/1000 cm^3)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME = ED X 365 days from noncarcinogens; or 70 yrs (lifetime exposure) X 365 days for carcinogens.

Constituent	"CW" Concentration (mg/l)	"SA" Skin Area (cm^2)	"ET" Exp. Time (hr/day)	"PC" Permeability Constant (cm/hr)	"EF" Expos. Freq. (days/year)	"BW" Body Weight (kg)	Lifetime Exposure (years)	"AT" Averaging Time (days)	"ED" Exposure Duration (years)	Absorbed Dose (mg/kg/day)	Dermal CSF (mg/kg/day)^-1	Cancer Risk	Dermal RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens														
Chloroform	0.001	7280	0.2	8.9E-03	350	15	70	25550	6	7.10E-08	6.10E-03	4.33E-10	NA	NA
1,2-Dichloroethane	0.001	7280	0.2	5.3E-03	350	15	70	25550	6	4.23E-08	9.10E-02	3.85E-09	NA	NA
1,1,2-Trichloroethane	0.001	7280	0.2	8.4E-03	350	15	70	25550	6	6.70E-08	7.04E-02	4.72E-09		
Arsenic	0.006	7280	0.2	1.6E-04	350	15	70	25550	6	7.66E-09	2.80E+00	2.14E-08	NA	NA
Noncarcinogens														
Chloroform	0.001	7280	0.2	8.9E-03	350	15	NA	2190	6	8.28E-07	NA	NA	1.00E-02	8.28E-05
1,2-Dichloroethane	0.001	7280	0.2	5.3E-03	350	15	NA	2190	6	4.93E-07	NA	NA	ND	ND
1,1,2-Trichloroethane	0.001	7280	0.2	8.4E-03	350	15	NA	2190	6	7.82E-07	NA	NA	3.24E-03	2.41E-04
Arsenic	0.006	7280	0.2	1.6E-04	350	15	NA	2190	6	8.94E-08	NA	NA	1.80E-04	4.96E-04
											SUMMATION:	3.04E-08		8.21E-04

Notes:
NA = Not Applicable
ND = Not Determined

AR303592

17-Jun-96
02:56 PM
8-IHSHWROF.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Scenario: Inhalation Of Chemical Constituents In Off-Site Residential Groundwater While Showering

Receptor: ADULT

Intake (mg/kg/day) = (SD * EF * ED) / AT

Cancer Risk = Intake (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Intake (mg/kg/day) / RfD (mg/kg/day)

WHERE:
Intake = Chronic Daily Intake (mg/kg/day)
SD = Constituent Dose From Shower (mg/kg/shower)
EF = Exposure Frequency (showers/year)
ED = Exposure Duration (years)
AT = Averaging Time = ED X 365 days for noncarcinogens; or 70 years (lifetime exposure) X 365 days for carcinogens.

Compound	"SD" Shower Dose (mg/kg/shower)	"EF" Exposure Freq. (showers/yr)	"ED" Exp. Duration (years)	Lifetime Exposure (years)	"AT" Averaging Time (days)	Intake (mg/kg/day)	Inhalation CSF (mg/kg/day)^-1	Cancer Risk	Inhalation RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens										
Chloroform	0.00004	350	30	70	25550	1.59E-05	8.1E-02	1.28E-06	NA	NA
1,2-Dichloroethane	0.00004	350	30	70	25550	1.55E-05	9.1E-02	1.41E-06	NA	NA
1,1,2-Trichloroethane	0.00003	350	30	70	25550	1.39E-05	5.6E-02	7.80E-07	NA	NA
Noncarcinogens										
Chloroform	0.00004	350	30	NA	10950	3.70E-05	NA	NA	ND	ND
1,2-Dichloroethane	0.00004	350	30	NA	10950	3.62E-05	NA	NA	2.86E-03	1.27E-02
1,1,2-Trichloroethane	0.00003	350	30	NA	10950	3.25E-05	NA	NA	ND	ND
							SUMMATION:	3.48E-06		1.27E-02

Notes:
NA = Not Applicable
ND = Not Determined

AR303593

17-Jun-96
02:40 PM
9-IHOFFA.WK1

Site Name: BERKS LANDFILL, BERK COUNTY, PENNSYLVANIA
Inhalation Of Chemical Constituents In Air By Off-site Receptor

Receptor: ADULT

Intake = CA * IR * ET * EF * ED/ (BW * AT)
(mg/kg/day)

Cancer Risk = Intake (mg/kg/da X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Intake (mg/kg/day) / RfD (mg/kg/day)

WHERE:
- CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
- IR = INHALATION RATE (m^3/hour)
- ET = EXPOSURE TIME (hours/day)
- EF = EXPOSURE FREQUENCY (days/year)
- ED = EXPOSURE DURATION (years)
- BW = BODY WEIGHT (kg)
- AT = AVERAGING TIME = ED X 365 days for noncarcinogens; or 70 yrs (lifetime exposure) X 365 days for carcinogens.

Constituent	"CA" Concentration (mg/m^3)	"IR" Inhalation Rate (m^3/hr)	"ET" Exposure Time (hours/day)	"BW" Body Weight (kg)	"EF" Exposure Frequency (days/year)	"ED" Exposure Duration (years)	Lifetime Exposure (years)	"AT" Averaging Time (days)	Intake (mg/kg/day)	Inhalation CSF (mg/kg/d)^-1	Cancer Risk	Inhalation RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens													
Benzene	1.86E-03	0.83	0.44	70	350	30	70	25550	4.00E-06	2.9E-02	1.16E-07	NA	NA
Trichloroethene	4.24E-03	0.83	0.44	70	350	30	70	25550	9.12E-06	6.0E-03	5.47E-08	NA	NA
Vinyl Chloride	3.03E-02	0.83	0.44	70	350	30	70	25550	6.52E-05	3.0E-01	1.96E-05	NA	NA
Noncarcinogens													
Benzene	1.86E-03	0.83	0.44	70	350	30	NA	10950	9.34E-06	NA	NA	1.70E-03	5.49E-03
Chlorobenzene	2.42E-03	0.83	0.44	70	350	30	NA	10950	1.22E-05	NA	NA	5.70E-03	2.13E-03
Chloroethane	3.23E-03	0.83	0.44	70	350	30	NA	10950	1.62E-05	NA	NA	2.86E+00	5.67E-06
Dichlorodifluoromethane	1.33E-02	0.83	0.44	70	350	30	NA	10950	6.68E-05	NA	NA	5.71E-02	1.17E-03
cis-1,2-Dichloroethene	8.68E-03	0.83	0.44	70	350	30	NA	10950	4.36E-05	NA	NA	ND	ND
Ethylbenzene	2.83E-01	0.83	0.44	70	350	30	NA	10950	1.42E-03	NA	NA	2.86E-01	4.97E-03
Hydrogen Sulfide	3.64E-02	0.83	0.44	70	350	30	NA	10950	1.83E-04	NA	NA	2.57E-04	7.11E-01
Toluene	1.37E-01	0.83	0.44	70	350	30	NA	10950	6.88E-04	NA	NA	1.14E-01	6.03E-03
Trichloroethene	4.24E-03	0.83	0.44	70	350	30	NA	10950	2.13E-05	NA	NA	ND	ND
1,2,4-Trimethylbenzene	4.24E-02	0.83	0.44	70	350	30	NA	10950	2.13E-04	NA	NA	ND	ND
1,3,5-Trimethylbenzene	2.42E-02	0.83	0.44	70	350	30	NA	10950	1.22E-04	NA	NA	ND	ND
Vinyl Chloride	3.03E-02	0.83	0.44	70	350	30	NA	10950	1.52E-04	NA	NA	ND	ND
Total Xylenes	6.66E-01	0.83	0.44	70	350	30	NA	10950	3.34E-03	NA	NA	ND	ND
										SUMMATION:	1.97E-05		7.31E-01

Notes:
NA = Not Applicable
ND = Not Determined

AR303594

06/17/96
02:36 PM
10-INGGWOSA.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Ingestion Of Chemical Constituents In On-Site Groundwater

Receptor: ADULT

Intake (mg/kg/day) = (CW * IR * EF * ED)/(BW * AT)

Cancer Risk = Intake (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Intake (mg/kg/day) / RfD (mg/kg/day)

WHERE:
CW = CONCENTRATION OF CONSTITUENT IN WATER (mg/l)
IR = INGESTION RATE (l/day)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATION (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME = ED X 365 days for noncarcinogens; or 70 yrs (lifetime exposure) X 365 days for carcinogens.

Constituent	"CW" Concentratio (mg/l)	"IR" Ingestion Rate (l/day)	"EF" Expos. Freq. (days/year)	"BW" Body Weight (kg)	Lifetime Exposure (years)	"AT" Averaging Time (days)	"ED" Exposure Duration (years)	Intake (mg/kg/day)	Oral CSF (mg/kg/day)^-1	Cancer Risk	Oral RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens												
Benzene	0.005	2	350	70	70	25550	24	4.70E-05	2.9E-02	1.36E-06	NA	NA
Chloromethane	0.005	2	350	70	70	25550	24	4.70E-05	1.3E-02	6.11E-07	NA	NA
1,4-Dichlorobenzene	0.007	2	350	70	70	25550	24	6.58E-05	2.40E-02	1.58E-06	NA	NA
1,2-Dichloroethane	0.002	2	350	70	70	25550	24	1.88E-05	9.1E-02	1.71E-06	NA	NA
1,1-Dichloroethene	0.001	2	350	70	70	25550	24	9.39E-06	6.0E-01	5.64E-06	NA	NA
bis(2-ethylhyexyl)Phthalate	0.008	2	350	70	70	25550	24	7.51E-05	1.4E-02	1.05E-06	NA	NA
Hexachloroethane	0.004	2	350	70	70	25550	24	3.76E-05	1.4E-02	5.26E-07	NA	NA
Trichloroethene	0.005	2	350	70	70	25550	24	4.70E-05	1.1E-02	5.17E-07	NA	NA
Vinyl Chloride	0.022	2	350	70	70	25550	24	2.07E-04	1.9E+00	3.93E-04	NA	NA
Arsenic	0.008	2	350	70	70	25550	24	7.51E-05	1.7E+00	1.28E-04	NA	NA
Beryllium	0.002	2	350	70	70	25550	24	1.88E-05	4.3E+00	8.08E-05	NA	NA

AR303595

06/17/96
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INGGWOSA.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Ingestion Of Chemical Constituents In On-Site Groundwater

Receptor: ADULT

Constituent	"CW" Concentratio (mg/l)	"IR" Ingestion Rate (l/day)	"EF" Expos. Freq. (days/year)	"BW" Body Weight (kg)	Lifetime Exposure (years)	"AT" Averaging Time (days)	"ED" Exposure Duration (years)	Intake (mg/kg/day)	Oral CSF (mg/kg/day)^-1	Cancer Ris	Oral RfD (mg/kg/day)	"HI" Hazard Index
Noncarcinogens												
Benzene	0.005	2	350	70	NA	8760	24	1.37E-04	NA	NA	ND	ND
Carbon Disulfide	0.003	2	350	70	NA	8760	24	8.22E-05	NA	NA	1.0E-01	8.22E-04
Chlorobenzene	0.010	2	350	70	NA	8760	24	2.74E-04	NA	NA	2.0E-02	1.37E-02
Chloromethane	0.005	2	350	70	NA	8760	24	1.37E-04	NA	NA	ND	ND
1,4-Dichlorobenzene	0.007	2	350	70	NA	8760	24	1.92E-04	NA	NA	ND	ND
1,2-Dichloroethane	0.002	2	350	70	NA	8760	24	5.48E-05	NA	NA	ND	ND
1,1-Dichloroethene	0.001	2	350	70	NA	8760	24	2.74E-05	NA	NA	9.0E-03	3.04E-03
Total 1,2-Dichloroethene	0.017	2	350	70	NA	8760	24	4.66E-04	NA	NA	9.0E-03	5.18E-02
bis(2-Ethylheyxyl)Phthalate	0.008	2	350	70	70	8760	24	2.19E-04	NA	NA	2.0E-02	1.10E-02
Hexachloroethane	0.004	2	350	70	NA	8760	24	1.10E-04	NA	NA	1.0E-03	1.10E-01
Trichloroethene	0.005	2	350	70	NA	8760	24	1.37E-04	NA	NA	6.0E-03	2.28E-02
Vinyl Chloride	0.022	2	350	70	NA	8760	24	6.03E-04	NA	NA	ND	ND
Aluminum	55.700	2	350	70	NA	8760	24	1.53E+00	NA	NA	1.0E+00	1.53E+00
Arsenic	0.008	2	350	70	NA	8760	24	2.19E-04	NA	NA	3.0E-04	7.31E-01
Barium	0.610	2	350	70	NA	8760	24	1.67E-02	NA	NA	7.0E-02	2.39E-01
Beryllium	0.002	2	350	70	NA	8760	24	5.48E-05	NA	NA	5.0E-03	1.10E-02
Cadmium	0.011	2	350	70	NA	8760	24	3.01E-04	NA	NA	5.0E-04	6.03E-01
Copper	0,146	2	350	70	NA	8760	24	4.00E-03	NA	NA	3.7E-02	1.08E-01
Manganese	6.670	2	350	70	NA	8760	24	1.83E-01	NA	NA	5.0E-03	3.65E+01
Nickel	0.036	2	350	70	NA	8760	24	9.86E-04	NA	NA	2.0E-02	4.93E-02
Vanadium	0.059	2	350	70	NA	8760	24	1.62E-03	NA	NA	7.0E-03	2.31E-01
									SUMMATION:	6.14E-04		4.03E+01

Notes:
NA = Not Applicable
ND = Not Determined

AR303596

06/17/96
02:35 PM
11-INGGWOSC.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Ingestion of Chemical Constituents in On-Site Groundwater

Receptor: CHILD

Intake = (CW * IR * EF * ED)/(BW * AT)
(mg/kg/day)

Cancer Risk = Intake (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Intake (mg/kg/day) / fD (mg/kg/day)

WHERE:
CW = CONCENTRATION OF CONSTITUENT IN WATER (mg/l)
IR = INGESTION RATE (l/day)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATION (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME = ED X 365 days for carcinogens; or 70 yrs (lifetime exposure) X 365 days for carcinogens.

Constituent	"CW" Concentration (mg/l)	"IR" Ingestion Rate (l/day)	"EF" Expos. Freq. (days/year)	"BW" Body Weight (kg)	Lifetime Exposure (years)	"AT" Averaging Time (days)	"ED" Exposure Duration (years)	Intake (mg/kg/day)	Oral CSF (mg/kg/day)^-1	Cancer Risk	Oral RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens												
Benzene	0.005	1	350	15	70	25550	6	2.74E-05	2.9E-02	7.95E-07	NA	NA
Chloromethane	0.005	1	350	15	70	25550	6	2.74E-05	1.3E-02	3.56E-07	NA	NA
1,4-Dichlorobenzene	0.007	1	350	15	70	25550	6	3.84E-05	2.4E-02	9.21E-07	NA	NA
1,2-Dichloroethane	0.002	1	350	15	70	25550	6	1.10E-05	9.1E-02	9.97E-07	NA	NA
1,1-Dichloroethene	0.001	1	350	15	70	25550	6	5.48E-06	6.0E-01	3.29E-06	NA	NA
bis(2-Ethylhexyl)Phthalate	0.008	1	350	15	70	25550	6	4.38E-05	1.4E-02	6.14E-07	NA	NA
Hexachloroethane	0.004	1	350	15	70	25550	6	2.19E-05	1.4E-02	3.07E-07	NA	NA
Trichloroethene	0.005	1	350	15	70	25550	6	2.74E-05	1.1E-02	3.01E-07	NA	NA
Vinyl Chloride	0.022	1	350	15	70	25550	6	1.21E-04	1.9E+00	2.29E-04	NA	NA
Arsenic	0.008	1	350	15	70	25550	6	4.38E-05	1.7E+00	7.45E-05	NA	NA
Beryllium	0.002	1	350	15	70	25550	6	1.10E-05	4.3E+00	4.71E-05	NA	NA

AR303597

06/17/96
02:35 PM
INGGWOSC.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Ingestion of Chemical Constituents in On-Site Groundwater

Receptor: CHILD

Constituent	"CW" Concentration (mg/l)	"IR" Ingestion Rate (l/day)	"EF" Expos. Freq. (days/year)	"BW" Body Weight (kg)	Lifetime Exposure (years)	"AT" Averaging Time (days)	"ED" Exposure Duration (years)	Intake (mg/kg/day)	Oral CSF (mg/kg/day)^-1	Cancer Risk	Oral RfD (mg/kg/day)	"HI" Hazard Index
Noncarcinogens												
Benzene	0.005	1	350	15	NA	2190	6	3.20E-04	NA	NA	ND	ND
Carbon Disulfide	0.003	1	350	15	NA	2190	6	1.92E-04	NA	NA	1.0E-01	1.92E-03
Chlorobenzene	0.010	1	350	15	NA	2190	6	6.39E-04	NA	NA	2.0E-02	3.20E-02
Chloromethane	0.005	1	350	15	NA	2190	6	3.20E-04	NA	NA	ND	ND
1,4-Dichlorobenzene	0.007	1	350	15	NA	2190	6	4.47E-04	NA	NA	ND	ND
1,2-Dichloroethane	0.002	1	350	15	NA	2190	6	1.28E-04	NA	NA	ND	ND
1,1-Dichloroethene	0.001	1	350	15	NA	2190	6	6.39E-05	NA	NA	9.0E-03	7.10E-03
Total 1,2-Dichloroethene	0.017	1	350	15	NA	2190	6	1.09E-03	NA	NA	9.0E-03	1.21E-01
bis(2-Ethylhexyl)Phthalate	0.008	1	350	15	NA	2190	6	5.11E-04	NA	NA	2.0E-02	2.56E-02
Hexachloroethane	0.004	1	350	15	NA	2190	6	2.56E-04	NA	NA	1.0E-03	2.56E-01
Trichloroethene	0.005	1	350	15	NA	2190	6	3.20E-04	NA	NA	6.0E-03	5.33E-02
Vinyl Chloride	0.022	1	350	15	NA	2190	6	1.41E-03	NA	NA	ND	ND
Aluminum	55.700	1	350	15	NA	2190	6	3.56E+00	NA	NA	1.0E+00	3.56E+00
Arsenic	0.008	1	350	15	NA	2190	6	5.11E-04	NA	NA	3.0E-04	1.70E+00
Barium	0.610	1	350	15	NA	2190	6	3.90E-02	NA	NA	7.0E-02	5.57E-01
Beryllium	0.002	1	350	15	NA	2190	6	1.28E-04	NA	NA	5.0E-03	2.56E-02
Cadmium	0.011	1	350	15	NA	2190	6	7.03E-04	NA	NA	5.0E-04	1.41E+00
Copper	0.146	1	350	15	NA	2190	6	9.33E-03	NA	NA	3.7E-02	2.52E-01
Manganese	6.670	1	350	15	NA	2190	6	4.26E-01	NA	NA	5.0E-03	8.53E+01
Nickel	0.036	1	350	15	NA	2190	6	2.30E-03	NA	NA	2.0E-02	1.15E-01
Vanadium	0.059	1	350	15	NA	2190	6	3.77E-03	NA	NA	7.0E-03	5.39E-01
									SUMMATION:	3.58E-04		9.39E+01

Notes:
NA = Not Applicable
ND = Not Determined

AR303598

06/17/96
02:26 PM
12-DMBTHONC.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Dermal Contact with Chemical Constituents in On-Site Groundwater while Bathing

Receptor: *CHILD*

Absorbed Dose = (CW * SA * PC * ET * EF * ED * CFv)/(BW * AT)
(mg/kg/day)

Cancer Risk = Absorbed Dose (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Absorbed Dose (mg/kg/day) / RfD (mg/kg/day)

WHERE:

CW = CONCENTRATION OF CONSTITUENT IN WATER (mg/l)
SA = SKIN SURFACE AREA (cm^2)
PC = CHEMICAL-SPECIFIC DERMAL PERMEABILITY CONSTANT (cm/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
CFv = VOLUMETRIC CONVERSION FACTOR (1 liter/1000 cm^3)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME = ED X 365 days from noncarcinogens
or AT = 70 years (Lifetime Exposure) X 365 days for carcinogens.

Constituent	"CW" Concentration (mg/l)	"SA" Skin Area (cm^2)	"ET" Exp. Time (hr/day)	"PC" Permeability Constant (cm/hr)	"EF" Expos. Freq. (days/year)	"BW" Body Weight (kg)	Lifetime Exposur (years)	"AT" Averaging Time (days)	"ED" Exposure Duration (years)	Absorbed Dose (mg/kg/day)	Dermal CSF mg/kg/day)^-	Cancer Risk	Dermal RfD (mg/kg/day	"HI" Hazard Index
Carcinogens														
Benzene	0.005	7280	0.2	1.10E-01	350	15	70	25550	6	4.39E-06	2.90E-02	1.27E-07	NA	NA
Chloromethane	0.005	7280	0.2	4.20E-03	350	15	70	25550	6	1.68E-07	1.30E-02	2.18E-09	NA	NA
1,4-Dichlorobenzene	0.007	7280	0.2	6.20E-02	350	15	70	25550	6	3.46E-06	2.40E-02	8.31E-08	NA	NA
1,2-Dichloroethane	0.002	7280	0.2	5.30E-03	350	15	70	25550	6	8.46E-08	9.10E-02	7.70E-09	NA	NA
1,1-Dichloroethene	0.001	7280	0.2	1.60E-02	350	15	70	25550	6	1.28E-07	6.00E-01	7.66E-08	NA	NA
bis(2-Ethylhexyl)Phthalate	0.008	7280	0.2	3.30E-02	350	15	70	25550	6	2.11E-06	1.40E-02	2.95E-08	NA	NA
Hexachloroethane	0.004	7280	0.2	2.10E-01	350	15	70	25550	6	6.70E-06	1.40E-02	9.38E-08	NA	NA
Trichloroethene	0.005	7280	0.2	1.60E-02	350	15	70	25550	6	6.38E-07	1.12E-02	7.15E-09	NA	NA
Vinyl Chloride	0.022	7280	0.2	7.30E-03	350	15	70	25550	6	1.28E-06	1.90E+00	2.43E-06	NA	NA
Arsenic	0.008	7280	0.2	1.60E-04	350	15	70	25550	6	1.02E-08	2.80E+00	2.86E-08	NA	NA
Beryllium	0.002	7280	0.2	1.60E-04	350	15	70	25550	6	2.55E-09	4.30E+02	1.10E-06	NA	NA
Noncarcinogens														
Benzene	0.005	7280	0.2	1.10E-01	350	15	NA	2190	6	5.12E-05	NA	NA	ND	ND
Carbon Disulfide	0.003	7280	0.2	2.40E-02	350	15	NA	2190	6	6.70E-06	NA	NA	6.30E-02	1.06E-04
Chlorobenzene	0.010	7280	0.2	4.10E-02	350	15	NA	2190	6	3.82E-05	NA	NA	6.20E-03	6.16E-03
Chloromethane	0.005	7280	0.2	4.20E-03	350	15	NA	2190	6	1.95E-06	NA	NA	ND	ND
1,4-Dichlorobenzene	0.007	7280	0.2	6.20E-02	350	15	NA	2190	6	4.04E-05	NA	NA	ND	ND
1,2-Dichloroethane	0.002	7280	0.2	5.30E-03	350	15	NA	2190	6	9.87E-07	NA	NA	ND	ND
1,1-Dichloroethene	0.001	7280	0.2	1.60E-02	350	15	NA	2190	6	1.49E-06	NA	NA	9.00E-03	1.65E-04
Total 1,2-Dichloroethene	0.017	7280	0.2	1.00E-02	350	15	NA	2190	6	1.58E-05	NA	NA	9.00E-03	1.76E-03
bis(2-Ethylhexyl)Phthalate	0.008	7280	0.2	3.30E-02	350	15	NA	2190	6	2.46E-05	NA	NA	2.00E-02	1.23E-03
Hexachloroethane	0.004	7280	0.2	1.00E-02	350	15	NA	2190	6	3.72E-06	NA	NA	1.00E-03	3.72E-03
Trichloroethene	0.005	7280	0.2	1.60E-02	350	15	NA	2190	6	7.45E-06	NA	NA	5.86E-03	1.27E-03
Vinyl Chloride	0.002	7280	0.2	7.30E-03	350	15	NA	2190	6	1.36E-06	NA	NA	ND	ND
Aluminum	55.700	7280	0.2	1.60E-04	350	15	NA	2190	6	8.30E-04	NA	NA	1.50E-01	5.53E-03
Arsenic	0.008	7280	0.2	1.60E-04	350	15	NA	2190	6	1.19E-07	NA	NA	1.80E-04	6.62E-04
Barium	0.610	7280	0.2	1.60E-04	350	15	NA	2190	6	9.08E-06	NA	NA	3.50E-02	2.60E-04
Beryllium	0.002	7280	0.2	1.60E-04	350	15	NA	2190	6	2.98E-08	NA	NA	5.00E-05	5.96E-04
Cadmium	0.011	7280	0.2	1.00E-03	350	15	NA	2190	6	1.02E-06	NA	NA	2.50E-04	4.10E-03
Copper	0.146	7280	0.2	1.60E-04	350	15	NA	2190	6	2.17E-06	NA	NA	3.59E-02	6.06E-05
Manganese	6.670	7280	0.2	1.60E-04	350	15	NA	2190	6	9.93E-05	NA	NA	2.00E-04	4.97E-01
Nickel	0.036	7280	0.2	1.00E-04	350	15	NA	2190	6	3.35E-07	NA	NA	2.00E-03	1.68E-04
Vanadium	0.059	7280	0.2	1.60E-04	350	15	NA	2190	6	8.79E-07	NA	NA	7.00E-03	1.26E-04
											SUMMATION:	3.99E-06		5.23E-01

Notes:
NA = Not Applicable
ND = Not Determined

AR303599

17-Jun-96
02:58 PM
13-IHSHWRON.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Scenario: Inhalation of Chemical Constituents in On-Site Groundwater While Showering

Receptor: ADULT

Intake (mg/kg/day) = (SD * EF * ED) / AT

Cancer Risk = Intake (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Intake (mg/kg/day) / RfD (mg/kg/day)

WHERE:
Intake = Chronic Daily Intake (mg/kg/day)
SD = Constituent Dose From Shower (mg/kg/shower)
EF = Exposure Frequency (showers/year)
ED = Exposure Duration (years)
AT = Averaging Time = ED X 365 days for noncarcinogens; or 70 years (lifetime exposure) X 365 days for carcinogens.

Compound	"SD" Shower Dose (mg/kg/shower)	"EF" Exposure Freq. (showers/yr)	"ED" Exp. Duration (years)	Lifetime Exposure (years)	"AT" Averaging Time (days)	Intake (mg/kg/day)	Inhalation CSF (mg/kg/day)^-1	Cancer Risk	Inhalation RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens										
Benzene	0.00023	350	30	70	25550	9.58E-05	2.9E-02	2.78E-06	NA	NA
Chloromethane	0.00028	350	30	70	25550	1.14E-04	6.3E-03	7.17E-07	NA	NA
1,4-Dichlorobenzene	0.00025	350	30	70	25550	1.03E-04	ND	ND	NA	NA
1,2-Dichloroethane	0.00008	350	30	70	25550	3.11E-05	9.1E-02	2.83E-06	NA	NA
1,1-Dichloroethene	0.00001	350	30	70	25550	4.60E-06	1.8E-01	8.28E-07	NA	NA
Hexachloroethane	0.00010	350	30	70	25550	3.97E-05	1.4E-02	5.56E-07	NA	NA
Trichloroethene	0.00020	350	30	70	25550	8.01E-05	6.0E-03	4.81E-07	NA	NA
Vinyl Chloride	0.00144	350	30	70	25550	5.92E-04	3.0E-01	1.78E-04	NA	NA
Noncarcinogens										
Benzene	0.00023	350	30	30	10950	2.23E-04	NA	NA	1.70E-03	1.31E-01
Carbon Disulfide	0.00011	350	30	30	10950	1.07E-04	NA	NA	2.90E-03	3.70E-02
Chlorobenzene	0.00040	350	30	30	10950	3.84E-04	NA	NA	5.70E-03	6.73E-02
Chloromethane	0.00028	350	30	30	10950	2.66E-04	NA	NA	ND	ND
1,4-Dichlorobenzene	0.00025	350	30	30	10950	2.40E-04	NA	NA	2.30E-01	1.04E-03
1,2-Dichloroethane	0.00008	350	30	30	10950	7.25E-05	NA	NA	2.86E-03	2.53E-02
1,1-Dichloroethene	0.00001	350	30	30	10950	1.07E-05	NA	NA	ND	ND
Total 1,2-Dichloroethene	0.00074	350	30	30	10950	7.08E-04	NA	NA	ND	ND
Hexachloroethane	0.00010	350	30	30	10950	9.27E-05	NA	NA	ND	ND
Trichloroethene	0.00020	350	30	30	10950	1.87E-04	NA	NA	ND	ND
Vinyl Chloride	0.00144	350	30	30	10950	1.38E-03	NA	NA	ND	ND
							SUMMATION:	1.86E-04		2.62E-01

Notes:
NA = Not Applicable
ND = Not Determined

AR303600

06/17/96
02:34 PM
14-INGSOOSA.WK1

Site Name: Berks Landfill, Berks County, Pennsylvania
Incidental Ingestion of Chemical Constituents in On-Site Soil

Receptor: ADULT WORKER

Intake = (CS * IR * FI * CF * BF * EF * ED)/(BW * AT)
(mg/kg/day)

Cancer Risk = Intake (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

$$\text{Hazard Index} = \frac{\text{Intake (mg/kg/day)}}{\text{RfD (mg/kg/day)}}$$

WHERE:
CS = CONCENTRATION OF CONSTITUENT IN SOIL (mg/kg)
IR = INGESTION RATE (mg/day)
FI = FRACTION INGESTED FROM CONTAMINATED SOURCE (100%)
CF = CONVERSION FACTOR (1E-06 kg/mg)
BF = BIOAVAILABILITY FACTOR (1, unitless)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATON (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME = ED X 365 days for noncarcinogens; or 70 yrs (lifetime exposure) X 365 days for carcinogens.

Constituent	"CS" Concentration (mg/kg)	"IR" Ingest. Rate (mg/day)	"FI" Fraction Ing. (unitless)	"EF" Exp. Freq. (days/yr)	"ED" Exp. Duration (years)	"BW" Body Wt. (kg)	Lifetime Exposure (years)	"AT" Averaging Tim (days)	Intake (mg/kg/day)	Oral CSF (mg/kg/day)^-1	Cancer Risk	Oral RfD mg/kg/day	"HI" Hazard Index
Carcinogens													
Benzo(a)pyrene	2.94E-01	50	1	24	25	70	70	25,550	4.93E-09	7.3E+00	3.60E-08	NA	NA
Arsenic	1.28E+01	50	1	24	25	70	70	25,550	2.15E-07	1.7E+00	3.65E-07	NA	NA
Beryllium	1.37E+00	50	1	24	25	70	70	25,550	2.30E-08	4.3E+00	9.87E-08	NA	NA
Noncarcinogens													
Benzo(a)pyrene	2.94E-01	50	1	24	25	70	NA	9,125	1.38E-08	NA	NA	ND	ND
Arsenic	1.28E+01	50	1	24	25	70	NA	9,125	6.01E-07	NA	NA	3.0E-04	2.00E-03
Beryllium	1.37E+00	50	1	24	25	70	NA	9,125	6.43E-08	NA	NA	5.0E-03	1.29E-05
										SUMMATION:	5.00E-07		2.02E-03

Notes:
NA = Not Applicable
ND = Not Determined

AR303601

06/17/96
02:33 PM
15-INGSOOSC.WK1

Site Name: BERKS LANDFILL, BERKS COUNTY, PENNSYLVANIA
Incidental Ingestion of Chemicals in On-Site Soil

Receptor: CHILD, TRESPASSER

Intake (mg/kg/day) = (CS * IR * FI * BF * CF * EF * ED)/(BW * AT)

Cancer Risk = Intake (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Intake (mg/kg/day) / RfD (mg/kg/day)

HERE:
CS = CONCENTRATION OF CONSTITUENT IN SOIL (mg/kg)
IR = INGESTION RATE (mg/day)
FI = FRACTION INGESTED FROM CONTAMINATED SOURCE (100%)
CF = CONVERSION FACTOR (1E-06 kg/mg)
BF = BIOAVAILABILITY FACTOR (1, unitless)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATON (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME
AT = ED X 365 days for noncarcinogens;
or AT = 70 years (lifetime exposure) X 365 for carcinogens.

Constituent	"CS" Concentration (mg/kg)	"IR" Ingest. Rate (mg/day)	"FI" Fraction Ing. (unitless)	"EF" Exp. Freq. (days/yr)	"ED" Exp. Duration (years)	"BW" Body Wt. (kg)	Lifetime Exposure (years)	"AT" Averaging Time (days)	Intake (mg/kg/day)	Oral CSF (mg/kg/day)^-1	Cancer Risk	Oral RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens													
Benzo(a)pyrene	0.29	100	1	50	9	55	70	25,550	9.41E-09	7.3E+00	6.87E-08	NA	NA
Arsenic	12.80	100	1	50	9	55	70	25,550	4.10E-07	1.7E+00	6.97E-07	NA	NA
Beryllium	1.37	100	1	50	9	55	70	25,550	4.38E-08	4.3E+00	1.89E-07	NA	NA
Noncarcinogens													
Benzo(a)pyrene	0.29	100	1	50	9	55	NA	3,285	7.32E-08	NA	NA	ND	ND
Arsenic	12.80	100	1	50	9	55	NA	3,285	3.19E-06	NA	NA	3.0E-04	1.06E-02
Beryllium	1.37	100	1	50	9	55	NA	3,285	3.41E-07	NA	NA	5.0E-03	6.82E-05
										SUMMATION:	9.54E-07		1.07E-02

Notes:
NA = Not Applicable
ND = Not Determined

AR303602

17-Jun-96
02:39 PM
16-IHONAR.WK1

Site Name: BERKS LANDFILL, BERK COUNTY, PENNSYLVANIA
Inhalation Of Chemical Constituents In Air By On-Site Receptor

Receptor: ADULT RESIDENT

Intake = CA * IR * ET * EF * ED/ (BW * AT)
(mg/kg/day)

Cancer Risk = Intake (mg/kg/day X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = (mg/kg/day) / RfD (mg/kg/day)

WHERE:
CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
IR = INHALATION RATE (m^3/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATION (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME = ED X 365 days for noncarcinogens; or 70 yrs (lifetime exposure) X 365 days for carcinogens.

Constituent	"CA" Concentration (mg/m^3)	"IR" Inhalation Rate (m^3/hr)	"ET" Exposure Time (hours/day)	"BW" Body Weight (kg)	"EF" Exposure Frequency (days/year)	"ED" Exposure Duration (years)	Lifetime Exposure (years)	"AT" Averaging Time (days)	Intake (mg/kg/day)	Inhalation CSF (mg/kg/d)^-1	Cancer Risk	Inhalation RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens													
Benzene	9.83E-06	0.83	0.44	70	350	30	70	25550	2.12E-08	2.9E-02	6.13E-10	NA	NA
Trichloroethene	2.24E-05	0.83	0.44	70	350	30	70	25550	4.82E-08	6.0E-03	2.89E-10	NA	NA
Vinyl Chloride	1.60E-04	0.83	0.44	70	350	30	70	25550	3.44E-07	3.0E-01	1.03E-07	NA	NA
Noncarcinogens													
Benzene	9.83E-06	0.83	0.44	70	350	30	NA	10950	4.94E-08	NA	NA	1.70E-03	2.90E-05
Chlorobenzene	1.28E-05	0.83	0.44	70	350	30	NA	10950	6.43E-08	NA	NA	5.70E-03	1.13E-05
Chloroethane	1.71E-05	0.83	0.44	70	350	30	NA	10950	8.59E-08	NA	NA	2.86E+00	3.00E-08
Dichlorodifluoromethane	7.05E-05	0.83	0.44	70	350	30	NA	10950	3.54E-07	NA	NA	5.71E-02	6.20E-06
cis-1,2-Dichloroethene	4.60E-05	0.83	0.44	70	350	30	NA	10950	2.31E-07	NA	NA	ND	ND
Ethylbenzene	1.50E-03	0.83	0.44	70	350	30	NA	10950	7.53E-06	NA	NA	2.86E-01	2.63E-05
Hydrogen Sulfide	1.93E-04	0.83	0.44	70	350	30	NA	10950	9.69E-07	NA	NA	2.57E-04	3.77E-03
Toluene	7.27E-04	0.83	0.44	70	350	30	NA	10950	3.65E-06	NA	NA	1.14E-01	3.20E-05
Trichloroethene	2.24E-05	0.83	0.44	70	350	30	NA	10950	1.12E-07	NA	NA	ND	ND
1,2,4-Trimethylbenzene	2.24E-04	0.83	0.44	70	350	30	NA	10950	1.12E-06	NA	NA	ND	ND
1,3,5-Trimethylbenzene	1.28E-04	0.83	0.44	70	350	30	NA	10950	6.43E-07	NA	NA	ND	ND
Vinyl Chloride	1.60E-04	0.83	0.44	70	350	30	NA	10950	8.03E-07	NA	NA	ND	ND
Total Xylenes	3.53E-03	0.83	0.44	70	350	30	NA	10950	1.77E-05	NA	NA	ND	ND
										SUMMATION:	1.04E-07		3.88E-03

Notes:
NA = Not Applicable
ND = Not Determined

AR303603

17-Jun-96
02:39 PM
17-IHONA.WK1

Site Name: BERKS LANDFILL, BERK COUNTY, PENNSYLVANIA
Inhalation Of Chemical Constituents In Air By On-Site Receptor

Receptor: ADULT WORKER

Intake = CA * IR * ET * EF * ED/ (BW * AT)
(mg/kg/day)

Cancer Risk = Intake (mg/kg/da X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Intake (mg/kg/day) / RfD (mg/kg/day)

WHERE:
CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
IR = INHALATION RATE (m^3/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATION (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME = ED X 365 days for noncarcinogens; or 70 yrs (lifetime exposure) X 365 days for carcinogens.

Constituent	"CA" Concentration (mg/m^3)	"IR" Inhalation Rate (m^3/hr)	"ET" Exposure Time (hours/day)	"BW" Body Weight (kg)	"EF" Exposure Frequency (days/year)	"ED" Exposure Duration (years)	Lifetime Exposure (years)	"AT" Averaging Time (days)	Intake (mg/kg/day)	Inhalation CSF (mg/kg/d)^-1	Cancer Risk	Inhalation RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens													
Benzene	9.83E-06	0.83	8	70	24	25	70	25550	2.20E-08	2.9E-02	6.37E-10	NA	NA
Trichloroethene	2.24E-05	0.83	8	70	24	25	70	25550	5.01E-08	6.0E-03	3.00E-10	NA	NA
Vinyl Chloride	1.60E-04	0.83	8	70	24	25	70	25550	3.58E-07	3.0E-01	1.07E-07	NA	NA
Noncarcinogens													
Benzene	9.83E-06	0.83	8	70	24	25	NA	9125	6.15E-08	NA	NA	1.70E-03	3.62E-05
Chlorobenzene	1.28E-05	0.83	8	70	24	25	NA	9125	8.01E-08	NA	NA	5.70E-03	1.41E-05
Chloroethane	1.71E-05	0.83	8	70	24	25	NA	9125	1.07E-07	NA	NA	2.86E+00	3.74E-08
Dichlorodifluoromethane	7.05E-05	0.83	8	70	24	25	NA	9125	4.41E-07	NA	NA	5.71E-02	7.73E-06
cis-1,2-Dichloroethene	4.60E-05	0.83	8	70	24	25	NA	9125	2.88E-07	NA	NA	ND	ND
Ethylbenzene	1.50E-03	0.83	8	70	24	25	NA	9125	9.39E-06	NA	NA	2.86E-01	3.28E-05
Hydrogen Sulfide	1.93E-04	0.83	8	70	24	25	NA	9125	1.21E-06	NA	NA	2.57E-04	4.70E-03
Toluene	7.27E-04	0.83	8	70	24	25	NA	9125	4.55E-06	NA	NA	1.14E-01	3.99E-05
Trichloroethene	2.24E-05	0.83	8	70	24	25	NA	9125	1.40E-07	NA	NA	ND	ND
1,2,4-Trimethylbenzene	2.24E-04	0.83	8	70	24	25	NA	9125	1.40E-06	NA	NA	ND	ND
1,3,5-Trimethylbenzene	1.28E-04	0.83	8	70	24	25	NA	9125	8.01E-07	NA	NA	ND	ND
Vinyl Chloride	1.60E-04	0.83	8	70	24	25	NA	9125	1.00E-06	NA	NA	ND	ND
Total Xylenes	3.53E-03	0.83	8	70	24	25	NA	9125	2.21E-05	NA	NA	ND	ND
										SUMMATION	1.08E-07		4.83E-03

Notes:
NA = Not Applicable
ND = Not Determined

AR303604

17-Jun-96
02:38 PM
18-IHONC.WK1

Site Name: BERKS LANDFILL, BERK COUNTY, PENNSYLVANIA
Inhalation Of Chemical Constituents In Air By On-Site Receptor

Receptor: CHILD TRESPASSER

Intake = CA * IR * ET * EF * ED/ (BW * AT)
(mg/kg/day)

Cancer Risk = Intake (mg/kg/day) X Cancer Slope Factor (CSF) (mg/kg/day)^-1

Hazard Index = Intake (mg/kg/day) / RfD (mg/kg/day)

WHERE:
CA = CONSTITUENT CONCENTRATION IN AIR (mg/m^3)
IR = INHALATION RATE (m^3/hour)
ET = EXPOSURE TIME (hours/day)
EF = EXPOSURE FREQUENCY (days/year)
ED = EXPOSURE DURATION (years)
BW = BODY WEIGHT (kg)
AT = AVERAGING TIME = ED X 365 days for noncarcinogens; or 70 yrs (lifetime exposure) X 365 days for carcinogens.

Constituent	"CA" Concentration (mg/m^3)	"IR" Inhalation Rate (m^3/hr)	"ET" Exposure Time (hours/day)	"BW" Body Weight (kg)	"EF" Exposure Frequency (days/year)	"ED" Exposure Duration (years)	Lifetime Exposure (years)	"AT" Averaging Time (days)	Intake (mg/kg/day)	Inhalation CSF (mg/kg/d)^-1	Cancer Risk	Inhalation RfD (mg/kg/day)	"HI" Hazard Index
Carcinogens													
Benzene	9.83E-06	0.83	2.4	55	50	9	70	25550	6.29E-09	2.9E-02	1.83E-10	NA	NA
Trichloroethene	2.24E-05	0.83	2.4	55	50	9	70	25550	1.43E-08	6.0E-03	8.60E-11	NA	NA
Vinyl Chloride	1.60E-04	0.83	2.4	55	50	9	70	25550	1.02E-07	3.0E-01	3.07E-08	NA	NA
Noncarcinogens													
Benzene	9.83E-06	0.83	2.4	55	50	9	NA	3285	4.89E-08	NA	NA	1.70E-03	2.88E-05
Chlorobenzene	1.28E-05	0.83	2.4	55	50	9	NA	3285	6.37E-08	NA	NA	5.70E-03	1.12E-05
Chloroethane	1.71E-05	0.83	2.4	55	50	9	NA	3285	8.51E-08	NA	NA	2.86E+00	2.98E-08
Dichlorodifluoromethane	7.05E-05	0.83	2.4	55	50	9	NA	3285	3.51E-07	NA	NA	5.71E-02	6.15E-06
cis-1,2-Dichloroethene	4.60E-05	0.83	2.4	55	50	9	NA	3285	2.29E-07	NA	NA	ND	ND
Ethylbenzene	1.50E-03	0.83	2.4	55	50	9	NA	3285	7.47E-06	NA	NA	2.86E-01	2.61E-05
Hydrogen Sulfide	1.93E-04	0.83	2.4	55	50	9	NA	3285	9.61E-07	NA	NA	2.57E-04	3.74E-03
Toluene	7.27E-04	0.83	2.4	55	50	9	NA	3285	3.62E-06	NA	NA	1.14E-01	3.18E-05
Trichloroethene	2.24E-05	0.83	2.4	55	50	9	NA	3285	1.12E-07	NA	NA	ND	ND
1,2,4-Trimethylbenzene	2.24E-04	0.83	2.4	55	50	9	NA	3285	1.12E-06	NA	NA	ND	ND
1,3,5-Trimethylbenzene	1.28E-04	0.83	2.4	55	50	9	NA	3285	6.37E-07	NA	NA	ND	ND
Vinyl Chloride	1.60E-04	0.83	2.4	55	50	9	NA	3285	7.97E-07	NA	NA	ND	ND
Total Xylenes	3.53E-03	0.83	2.4	55	50	9	NA	3285	1.76E-05	NA	NA	ND	ND
										SUMMATION:	3.10E-08		3.84E-03

Notes:
NA = Not Applicable
ND = Not Determined

AR303605

APPENDIX F

LEAD UPTAKE/BIOKINETIC MODEL RESULTS

APPENDIX F

LEAD UPTAKE/BIOKINETIC MODEL RESULTS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

ABSORPTION METHOD: Non-Linear Active-Passive

AIR CONCENTRATION: 0.100 ug Pb/m^3 default

Indoor Air Concentration: 30.0 percent of outdoor

Other Air Parameters:

Age	Time Outdoors (hr)	Ventilation Rate (m^3/day)	Lung Absorption (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: default

DRINKING WATER CONCENTRATION: 15.30 ug Pb/L
Water Consumption: default

SOIL & DUST:
Soil: constant concentration
Dust: constant concentration

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
0-1	14.6	14.6
1-2	14.6	14.6
2-3	14.6	14.6
3-4	14.6	14.6
4-5	14.6	14.6
5-6	14.6	14.6
6-7	14.6	14.6

Additional Dust Sources: None default

APPENDIX F (Cont'd)

LEAD UPTAKE/BIOKINETIC MODEL RESULTS
BERKS LANDFILL
BERKS COUNTY, PENNSYLVANIA

PAINT INTAKE: 0.0 ug Pb/day default

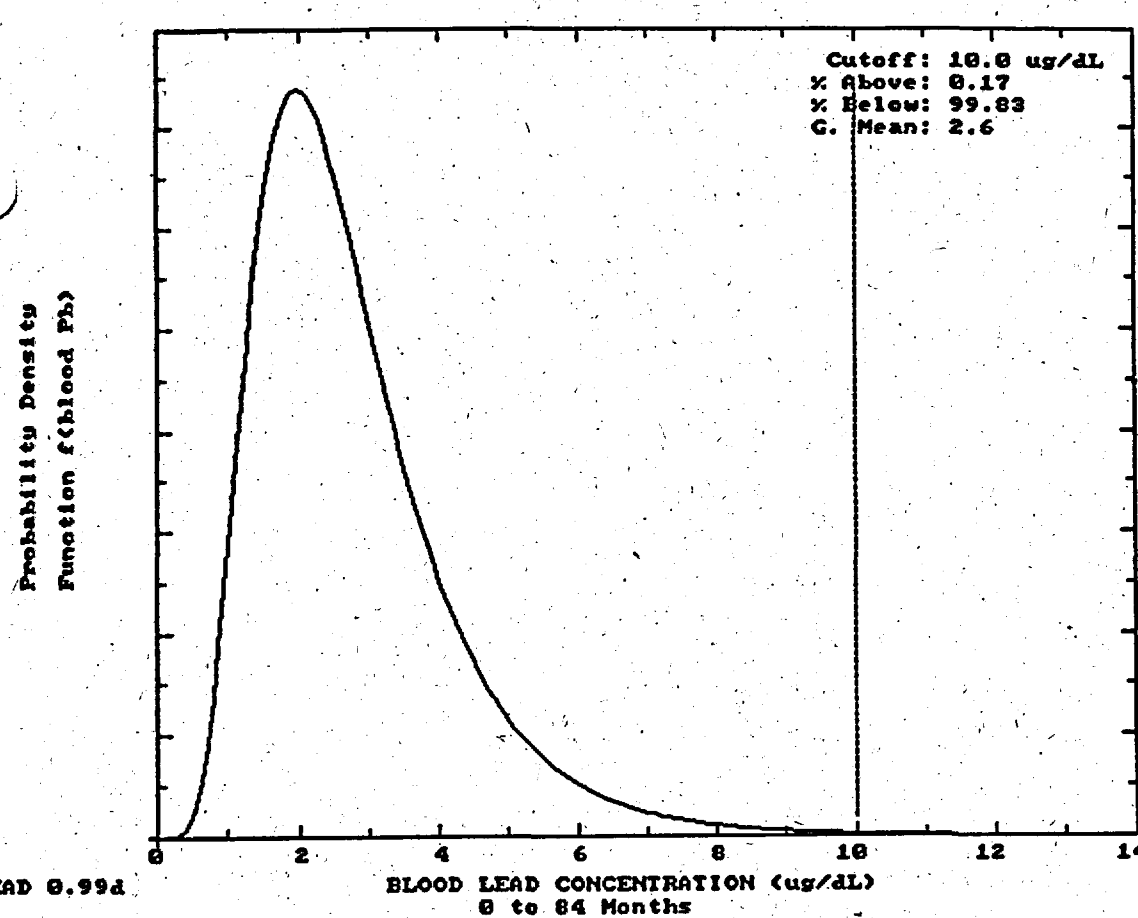
MATERNAL CONTRIBUTION: Infant Model

Maternal Blood Concentration: 2.50 ug Pb/dL

CALCULATED BLOOD Pb and Pb UPTAKES:

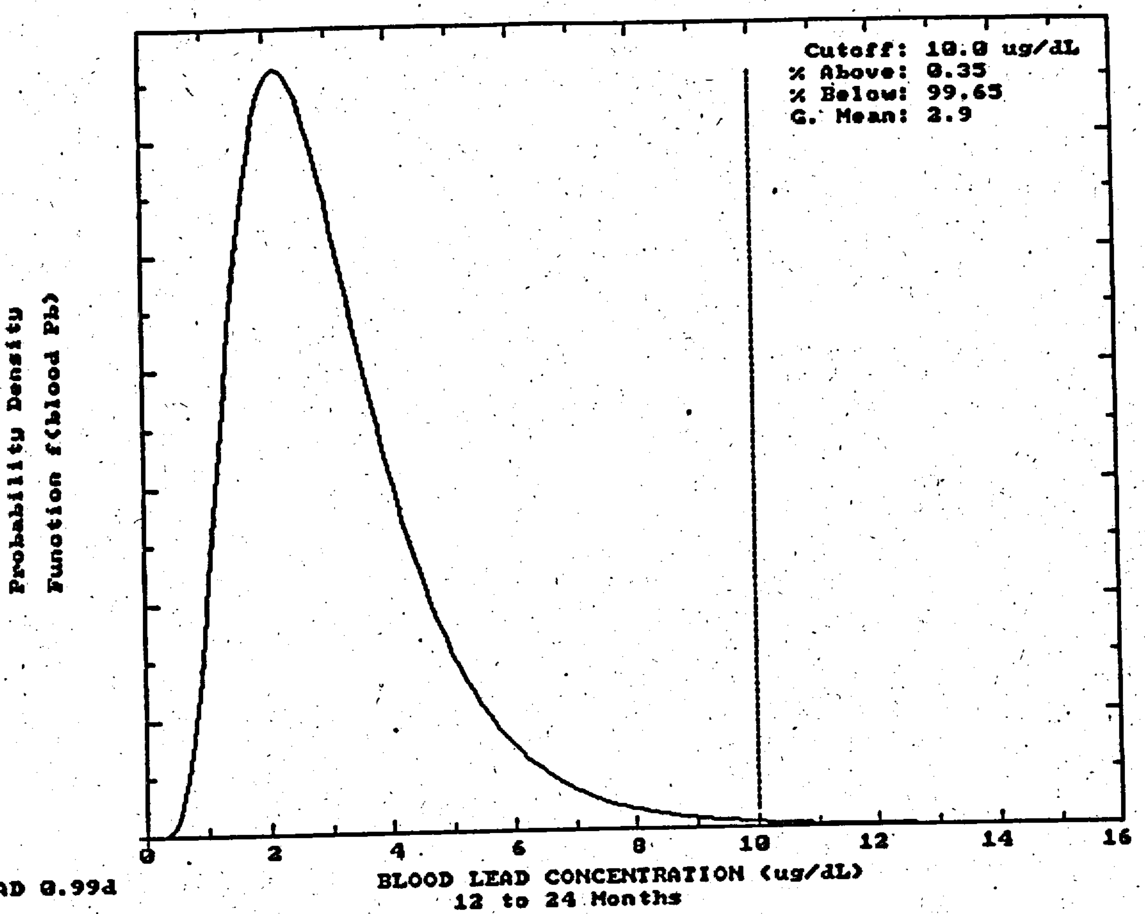
Year	Blood Level (ug/dL)	Total Uptake (ug/day)	Soil + Dust Uptake (ug/day)
0.5-1:	2.40	4.46	0.35
1-2:	2.90	6.91	0.56
2-3:	2.80	7.46	0.56
3-4:	2.60	7.48	0.56
4-5:	2.50	7.42	0.42
5-6:	2.40	7.80	0.38
6-7:	2.30	8.18	0.36

Year	Diet Uptake (ug/day)	Water Uptake (ug/day)	Paint Uptake (ug/day)	Air Uptake (ug/day)
0.5-1:	2.63	1.45	0.00	0.02
1-2:	2.72	3.60	0.00	0.03
2-3:	3.07	3.77	0.00	0.06
3-4:	2.98	3.87	0.00	0.07
4-5:	2.89	4.04	0.00	0.07
5-6:	3.05	4.27	0.00	0.09
6-7:	3.38	4.35	0.00	0.09



LEAD 0.99d

AR303609



LEAD 0.99d

AR303610